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SITE DESIGN FOR HILLSIDE DEVELOPMENT

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SITE DESIGN FOR HILLSIDE DEVELOPMENT

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LOS ANGELES, CA

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INTRODUCTION

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To preserve and protect, to the maximum extent possible, the unique and valuable natural resources and amenities of the City's environment, including topographic and geologic features, beaches and natural water courses, fish and wildlife habitats, historical and cultural places, and scenic vistas and attractions; and, to maximize the public's access to and enjoyment of such resources and amenities through the dedication or continuance of appropriate public easements thereto.

To preserve and protect the special environmental quality and aesthetic character of all hillside and mountainous areas in the City; to prevent detrimental impacts on the soil mantle, vegetative cover, and other environmental factors; to reduce the hazards to life and property from fire, flood, erosion, sedimentation and soil slippage; and, to relate the amount of grading within a subdivision to the slope of the natural terrain.

To encourage the clustering of housing developments in hillside and mountainous areas in order to minimize grading, preserve the natural terrain, and maximize open space.

To ensure adequate access to each building site.

To provide sidewalks, and where needed, pedestrian ways, biking paths, and equestrian and hiking trails for the safety, convenience, and enjoyment of the residents of new developments. (Section 1-800.15 Pg. 2 Subdivision Regulations, City of Los Angeles)

INTRODUCTION

The city has clearly stated its policy toward environmental design for hillside subdivision. But typical hillside residential developments clear land of its natural vegetation, cut away hilltops and fill ravines to make housing pads and roads. This results in unsightly, environmentally damaging and expensive tract development.

Developers have an opportunity to turn this policy into a well-defined sales tool for marketing a housing product. By implementing the City's policies, they may also appeal to the aesthetic and value oriented needs of the buying community. Solutions are available that address the City policy. At the same time the benefits of lower cost can make these solutions attractive to the developer and to the environmentally conscious public, who can see the exceptional value of a high quality, natural environment.

Engineering standards still sometimes impose flatland design on hillside land in ways that may conflict with above-stated policies. It will be beneficial for the city to review its standards for drainage and street design in the light of environmental concerns. On-site diversion of runoff could increase groundwater infiltration, ease sewer use and diminish imported water requirements. Retention basins could reduce conventional curb and gutter requirements. Streets could be narrowed and made of permeable materials, to lessen run-off, increase infiltration and result in less cut and fill. Costs could be less and the aesthetic value, which is related to market value, could increase. The opportu-

nity is available to blend hillside development with the natural landscape rather than conflict with it. The principles are not new. They are tried and proven. The challenge now is to implement the existing city policy and move toward an environmentally sensitive development. This is the purpose of this project.

Environmental site design is a useful tool the City of Los Angeles can employ to ensure that its future development carefully considers every site's unique features and natural qualities. Because the city lacks sufficient examples demonstrating good environmental site design practices, the City Planning Department commissioned the 606 Studio group of the California State Polytechnic University to develop guidelines along with an analytical process for environmental site design. An application of these principles, which are well developed in the practice of landscape architecture, is offered as a means to implement City policy toward preservation and management. The environmental site design will be illustrated with a case study from a representative hillside site. This can serve as a model approach to the stages of design. The city is urged to recognize the importance of establishing developer design strategies before a tentative tract map is submitted, if city policies are to be followed and the intended environmental benefits achieved. This process can lead to designs that will help to ensure the protection of the hillside resources as development continues to move up the slopes. Using the tools presented here, developers may be able to more easily meet some of the City's requirements for project approval. Together the City and the developers can make Los Angeles a

prototype of forward- thinking hillside design.

The project includes four interrelated sections:

- A PROCESS for developing a tentative tract map
- A method of SITE ANALYSIS
- A set of DESIGN GUIDELINES
- A procedure for designing ALTERNATIVES

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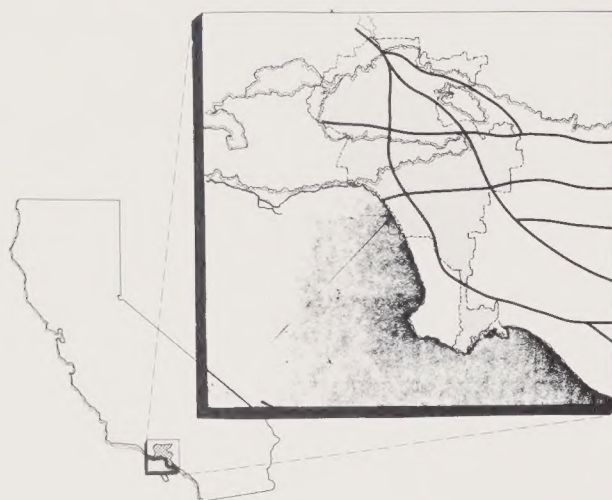
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BACKGROUND



HISTORY

Hillsides of Los Angeles are incredibly varied. Ringing the San Fernando and other valleys, they form a major part of the City's visual and ecological character. Today, the hills still have many untouched areas suitable for parks, recreation, and carefully planned development, but they are all different in both origin and character.

The hills and mountains that form the edges of the Los Angeles basin are part of the transverse range of southern California. This range trends from west to east and is shaped by the landward influence of the sea floor structure known as the *Murray Fracture Zone*. The range extends for 300 miles beginning with the Santa Ynez mountains in Santa Barbara County and ends with the Eagle Mountains in San Bernardino County. It includes the Channel Islands, the San Gabriel Mountains and the San Bernardino Mountains, the Santa Monica Mountains, the Simi Hills, the Santa Susana Mountains, and the Verdugo Hills. The latter four of these are located within the City of Los Angeles.

The Santa Monica Mountains extend from Elysian Park to the Oxnard Plain and from Griffith Park to Point Mugu. They cover an area of over 223,000 acres and are 46 miles in length with an average height of 1500-2000 feet. Composed of sedimentary rock from marine deposits, they were formed between 8 to 70 million years ago. They are familiar to most of us and conjure up visions of steep terrain and expensive houses. Much of the undeveloped land has been protected in

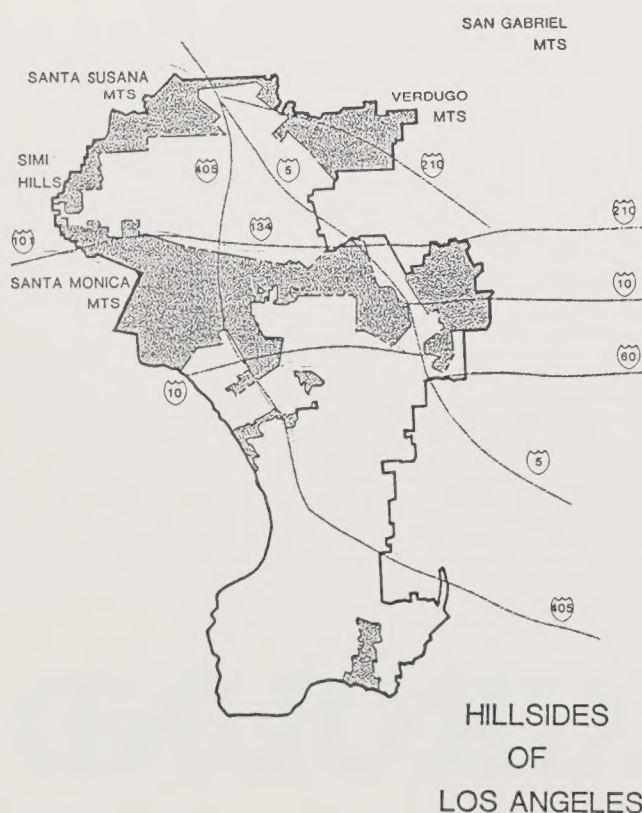
the Santa Monica Mountains National Recreation Area and in state parks; but large parcels, especially the steeper areas are still undeveloped.

The Simi Hills rose during the Cretaceous period, 80 to 100 million years ago when this northwest corner of the San Fernando valley lay just off the coast. Shale, sand, and huge boulders were all pressed and cemented into the conglomerate rock we see today, then raised along the fault and weathered through the ages. The range extends for 15 miles, and the average height is 2000 feet.

The Santa Susana Mountains are the youngest system in this area, formed approximately 2 to 24 million years ago. They are composed mainly of finely grained marine strata. This material gives the mountains a smooth look in comparison to the rough rugged Simis. The highest peak in this system is approximately 3700 feet.

The Verdugo Hills are the easternmost range of Los Angeles mountains. They are a fore-lying range of the San Gabriel mountains. They extend for seven miles in length with a height of no more than 2000 ft. Composed mostly of crystalline formations made up of igneous and metamorphic rock, they were formed over 200 million years ago.

The plant communities of the Los Angeles mountain ranges are similar: coastal sage, rugged chaparral, oak grasslands and riparian woodlands. The valley oak, the largest native oak in the U.S., at one time ranged from the Cascade foothills to the San Fernando Valley. Cattle grazing and fire wood gathering have seriously depleted their numbers. The Simi



Hills area harbors the largest remaining stand of this deciduous oak.

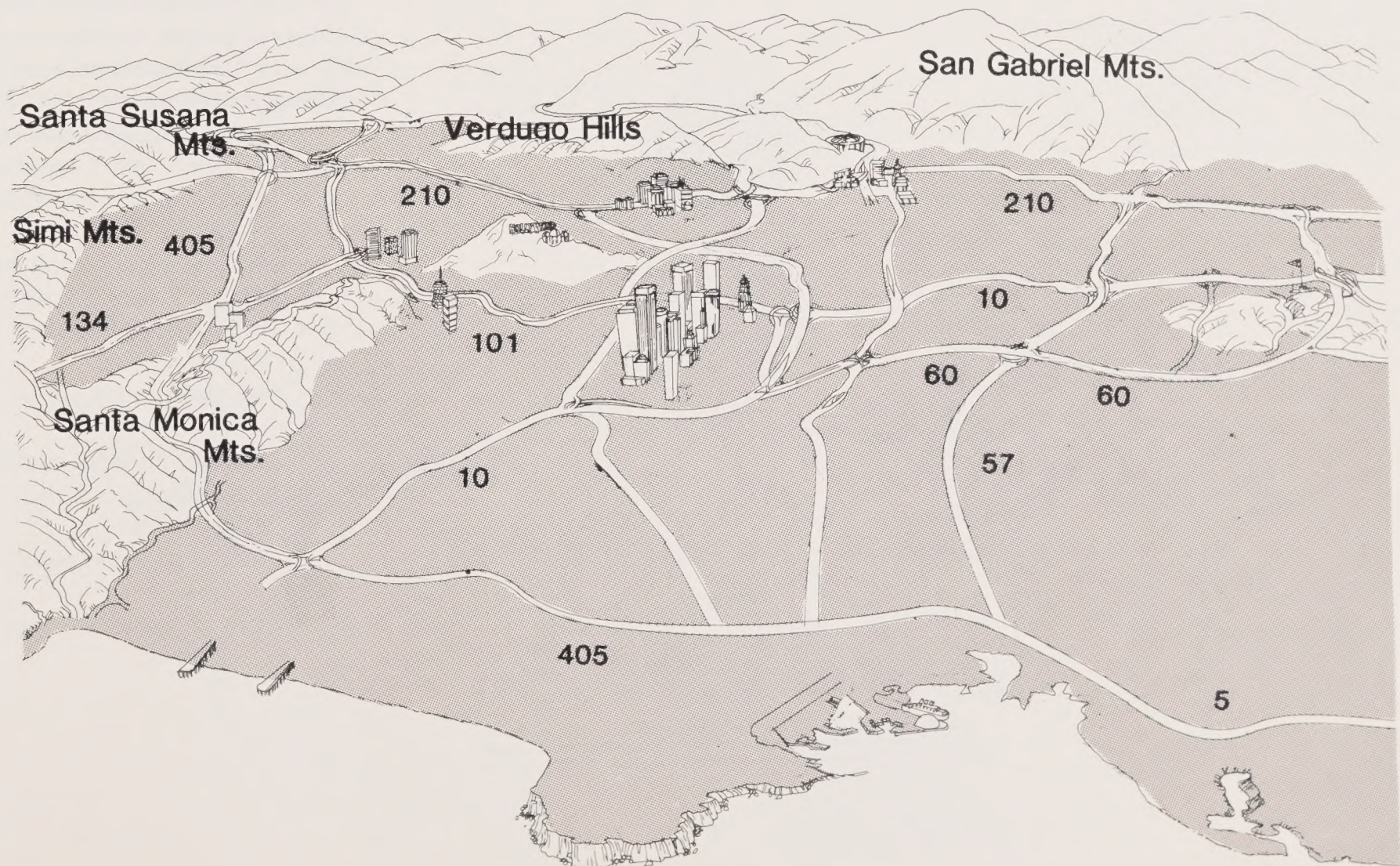
Today the animals in the undeveloped areas include coyotes, bobcats, golden eagles, and many species of birds, rodents and other small mammals.

For centuries, Chumash (Fernandino) and Shoshonean (Gabrieleno) Indian families hunted and gathered seeds in the mountains, fished its streams and built their villages near the major water courses. The Gabrieleno Indians considered the Simi hills sacred. Typical Indian relics like paintings, arrow-

heads and grinding holes are scattered throughout the hills.

The hills of Los Angeles have always provided visual relief from the flat valley floors. They are ecological havens for plant and animal species. Population changes and the ever indulgent attitudes of Californians have brought development to the hillsides, and a change in the ecological balance. Recently, movements to protect the hills have met resistance from those who would capitalize on the resources. Consequently, views from the hills to the valley floors or to the

ocean have become more valuable than the protected view of the hills from the valleys. Rapid development has taken its toll on the visual and ecological character of the hills. More often than not hillside subdivisions have produced ugly, dysfunctional patterns that use water and energy in recklessly large quantities, destroy natural ecosystems, and fail to provide environmental amenity to their residents. This project provides the means for better design. It is an effort to reconcile the economic and social needs for development while stressing the need for environmental quality.



ENVIRONMENTALLY SUITABLE DEVELOP- MENT

In order for good development to have meaning and definition a set of criteria must be set forth to bring a common understanding to the desired land use practices. This study will define environmentally suitable development as having these characteristics.

- Natural or landform graded slopes
- Appropriate slope planting
- Protection from hazards such as fire, flood and earthquake
- Sound drainage practices to protect people, wildlife, vegetation and water resources
- Circulation of people and vehicles planned in relation to topography
- Visual quality when viewed from off site
- Management to control run-off
- Siting of houses to save energy
- Protection of native trees, especially oaks
- Fuel modification for fire resistance
- Minimum disturbance of natural communities including wildlife habitat
- Siting of houses to maximize views.
- Siting of houses to reduce graded pad area

DEVELOPMENT COMMUNITY

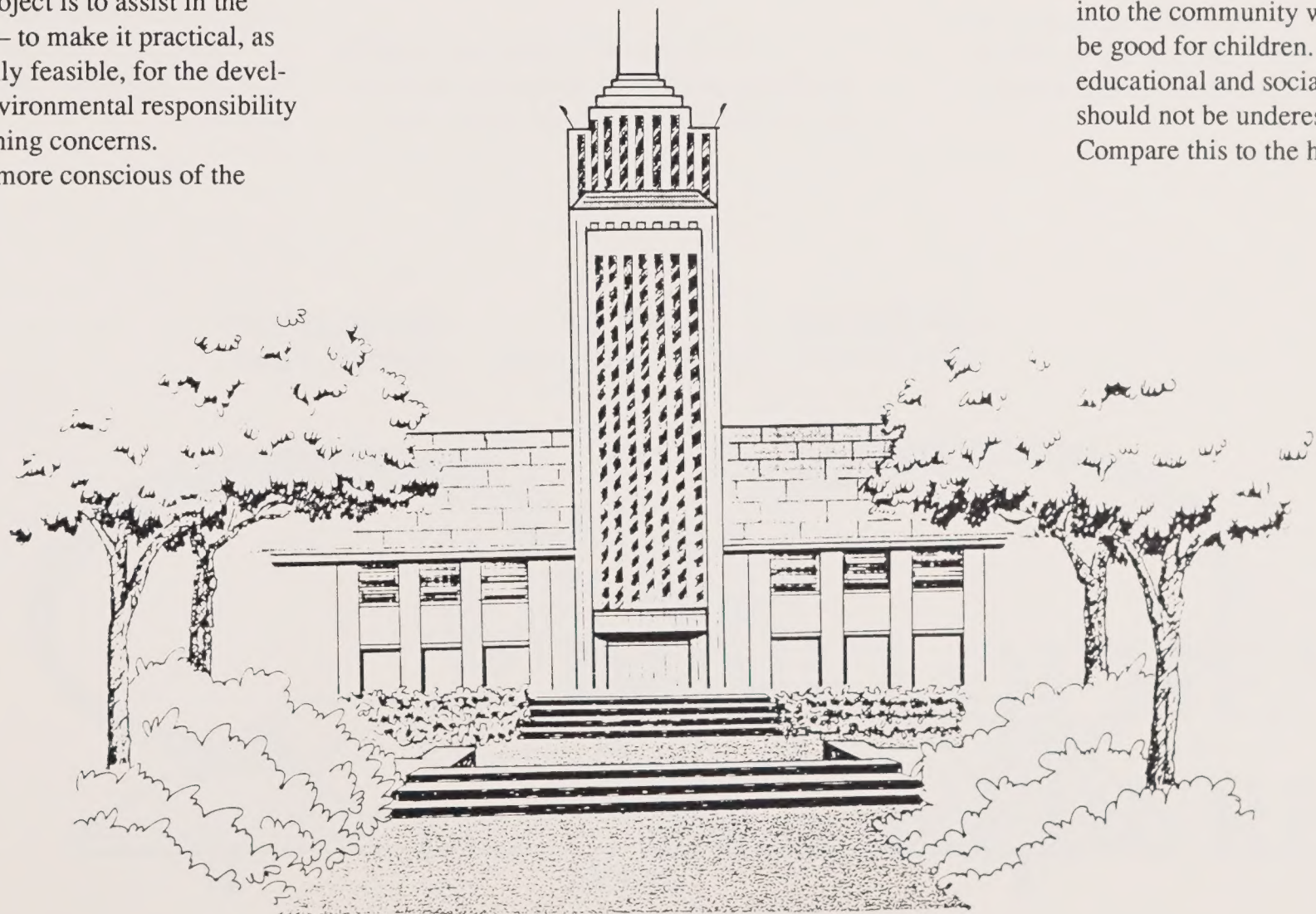
The developer has certain rights in relation to the property he owns. He wishes to realize a profit from his work and investment. He also knows that he is providing a service to the community. But environmental concerns are increasingly bringing on conflicts between developers and regulatory agencies. Many developers are having difficulty getting the required clearances for their projects, especially in hillside areas. The objective of this project is to assist in the planning process — to make it practical, as well as economically feasible, for the developer to exercise environmental responsibility and deal with planning concerns.

People are more conscious of the

environment than ever before. City policy, as has been demonstrated, is good policy and reflects the environmental desires and preferences of housing for many people today. The market is changing and the regulatory agencies are beginning to reflect that change. The process described in this report represents, for developers, a means of creating a bridge to environmentally benign development and therefore to project approval. Adherence will ease the movement through city regulations and lessen the possible resistance from neighbors. Increased market value due to environmentally sensitive design will ulti-

mately result. This could happen in several ways.

- Future risks of wildland fires can be minimized through vegetation management, while mitigating the public cost of fire suppression. It could also serve to restrict insurance costs — a measure certain to add sales value to a development.
- The natural processes provided by an environmentally sensitive design will integrate nature into the community which will be good for children. The educational and social value should not be underestimated. Compare this to the hard edge



of typical development. There can also be cost savings.

- Potential hazards such as unstable soils can be avoided. This results in a security for those investing in property.
- Amenities such as rock outcroppings and stands of native trees serve as focal points of a development and create an atmosphere many people are searching for.

The conventional approach to development in the hillsides is destructive and costly. Environmentally sensitive design

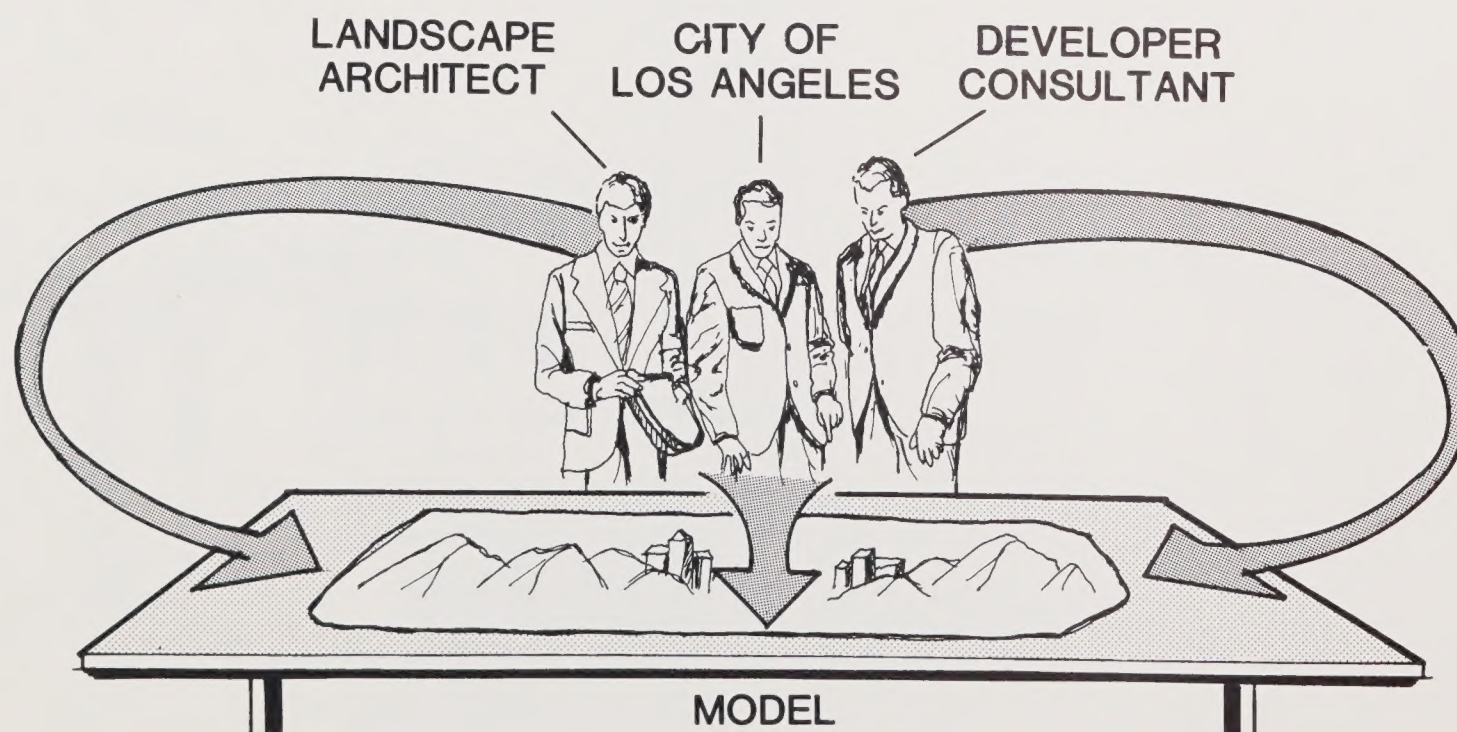
offers a favorable alternative which can minimize cost incurred by damaging and unsightly cut and fill.

To determine the site's most unique qualities and most appropriate land use respects the important features of the land. Developers and designers must be given the opportunity to exercise the principles of environmental site design. Landscape architects, trained in environmentally sensitive land design can bring an important perspective to the design process and by their training reduce the time necessary to get plan approval.

Often engineering concerns-- a narrow reading of regulatory requirements and a lack of attention to environmental issues--cause

development to be based mainly on cut and fill calculations. The best possible utilization of the land is not always a primary goal. Neither high density nor non-development may be the answer. It is the responsibility of the developer to determine the land use which is most appropriate to the site's unique qualities.

It is important that both developers and consultants be given the opportunity to exercise the principles of environmental site design. One approach the city could consider is to require the participation of a landscape architect to assist in the design phase. Landscape architects are specifically trained in environmentally sensitive land design and can bring this important perspective to the design process.



DEVELOPMENT PROCEDURE

ENVIRONMENTAL SITE DESIGN IN THE PROJECT REVIEW PROCEDURE

In current practice, the developer creates a subdivision concept, has a plan developed and brings it to the city to begin the approval process. In order to submit a tentative tract map, a developer must first get certain clearances. These clearances are time consuming and therefore costly to the developer who is anxious to move toward a return on his investment. Clearances include:

- Zoning variances if required
- Hillside Grading Clearance
- Environmental Clearance
- Coastal Unit Clearance within the coastal zone

Upon clearance, a tentative tract map is submitted, fees are paid and the map begins its course toward approval. It is necessary to consult with and obtain approval from numerous departments concerning required city ordinances. These include: Planning, Engineering, Building and Safety, Water & Power, Fire, Streets, Transportation, Recreation and Parks, Community Planning, Zoning, Telecommunications, and Health. It is not an easy journey and delays are a matter of course. The ultimate goal is approval of the Final Tract Map.

Environmental clearance is a major portion of the process for approval of a Tentative Tract Map and the best opportunity to ensure the city's environmental goals. It

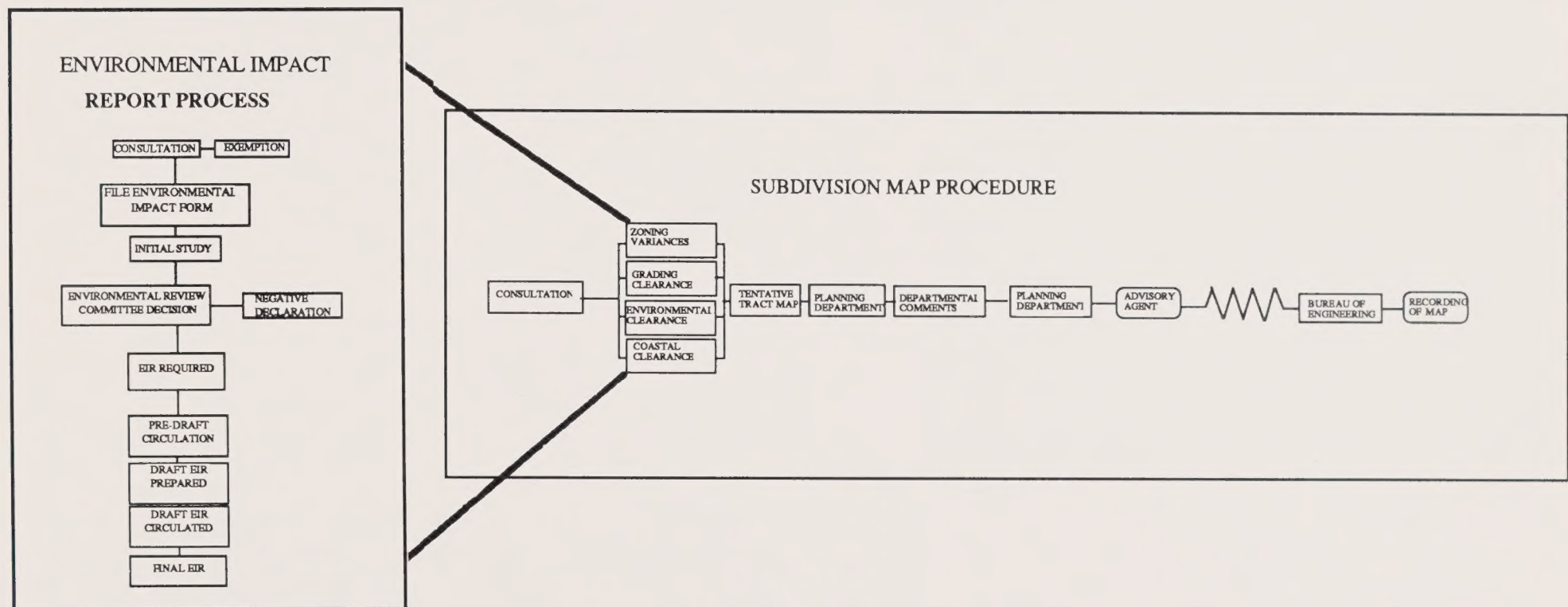
can also be costly to the developer if it occurs at an advanced stage of the design. The clearance process was created through The California Environmental Quality Act and includes the Environmental Impact Report. It can be an effective way to protect the natural resources of the area. Mandating a procedure for development, it considers the effect of development on the sensitivities of the land. But too often EIRs sound alike, as though they contain prepackaged information applicable to any site. By contrast, the information used for the EIR in the environmental site design process presented here will delve more deeply into the unique characteristics of a site.

In order to apply for environmental clearance the developer must fill out an Environmental Impact sheet. If there are any important impacts on the land the city requires an Environmental Impact Report. If there are no impacts of any consequence a Negative Declaration is given. The city requires an EIR for any hillside development having more than four units. One advantage of the EIR is the public response it elicits, but as presently instituted, it is a long, difficult process and there may be better ways to have the landowner look at his property. For example, planning departments in some other jurisdictions have development proposals reviewed by a group of experts in areas such as wildlife, native and endangered plants, and geology prior to design.

If the EIR process could be redirected to help the developer produce an environmentally sensitive Tentative Tract

Map, then later approvals could be simplified and time saved. Given the right tools the developer could study the land and produce several alternatives for land use. A means of evaluating these alternatives in terms of environmental sensitivity and economic value might also reduce the delay time in the city approval process. It would be most beneficial for developers to be introduced to such a process *before* any land planning time or expense has been incurred. However, at the present time the city has no consultation requirement for the developer before a Tentative Tract Map is made. It is our recommendation that this be changed.

The second appropriate use of the process comes at the point where an EIR has been requested and a design review takes place. Because the environmental site design leads to well designed alternatives it could be integrated into the beginning stages of the EIR process. In fact, a more thorough and specific understanding of the land would make the EIR a more viable document.



SITE DESIGN PROCESS

SITE DESIGN PROCESS INTRODUCTION

The environmentally responsive process for developing a tentative tract map presented here responds to the needs of the city and the needs of the developers. It takes into consideration the City requirements. The flow chart shows the process. It proceeds through site analysis, determination of land suitability and design guidelines to alternatives based on the unique features of the particular site in question. The chart begins with the landowner's decision to develop. It should be emphasized that this is a "how-to" process. It is not intended to show the right plan, but rather to illustrate a means of getting to the best plan. Each site is different and each designer will respond to that land in a unique way. By applying the process, plans can evolve out of the specific environmental characteristics of the land. At the same time, careful design will speed up city approvals saving time and, therefore, money for the developer.

SITE DESIGN PROCESS OUTLINE

ECOLOGY AND DEVELOPMENT

Plant and Animal Cycle—shows hierarchy of plants and animals in the ecological balance

Hydrology Models—show amounts of water on site in several situations

Short versus Long Term Cost Model--compares costs for each alternative

SITE INVENTORY

Opening Questions--determines which inventory maps are necessary

Inventory Questions and Maps—describes site in terms of natural geographic factors and provides inventory maps at a consistent scale

SUITABILITY ANALYSIS

Suitability Matrix—shows relationship between natural factors and possible land use

Site Checklist--lists natural characteristics of a particular site.

Rules of Combination--Establishes priorities and values of natural factors relative to land use

Suitability Model—Using rules, the areas of greatest suitability for various land uses are mapped.

DESIGN GUIDELINES—

Design Guidelines —Illustrated guidelines for hillside development

ALTERNATIVES

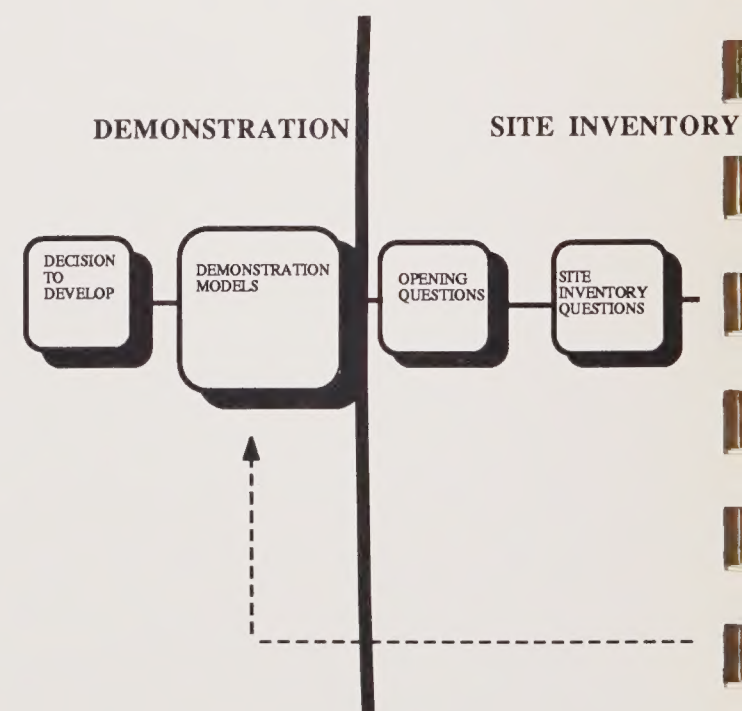
Alternatives—creation of alternatives

COMPARATIVE ANALYSIS

Sensitivity Matrix and Map - examines alternatives in terms of effects on the natural characteristics of the site.

In order to graphically demonstrate the process, it is useful to use a specific piece of land for case study purposes. Site Inventory, suitability analysis and alternatives will be illustrated using information describing a real site. However, the location of this land will not be given. It is representative of many

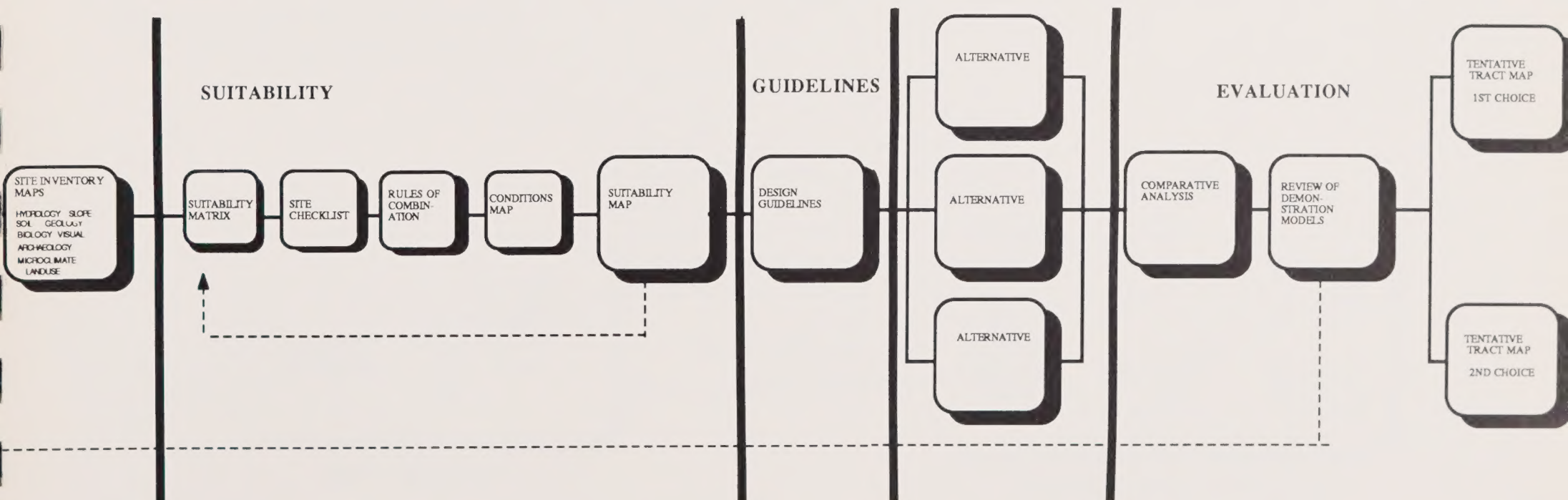
SITE DESIGN PROCESS



hillside sites in Los Angeles. City ordinances have been considered on a city-wide basis rather than conforming only to the specific plan of the area where the site is located. Some characteristics of the land and its surroundings have been changed in the analyses in order to illustrate a broader range of conditions. Therefore, the plans presented here should not be considered as actual plans, but as illustrations. Each site considered for development should be examined for its unique qualities and planned using the ordinances suitable for the particular area.

The case study site consists of 200 acres of land in the Los Angeles area mountains. The terrain is steep and vegetation is generally chaparral. A strong ridgeline follows the south edge of the property. A second ridgeline crosses the center of the property and was severely altered in the past. A deep canyon provides a riparian area which no doubt supports wildlife, but is a place where the wildlife corridor does not have a well defined exit from the site. Horsekeeping

is significant in the area and must be considered with all plans. Access is somewhat difficult and creative solutions must be found. The Community Plan designates its maximum density as one dwelling unit for every two acres. For clarity, information dealing directly with the case study will be shown in italics.



DEMONSTRATION MODELS

ECOLOGY

DEMONSTRATION MODELS

ECOLOGY AND DEMONSTRATION MODELS

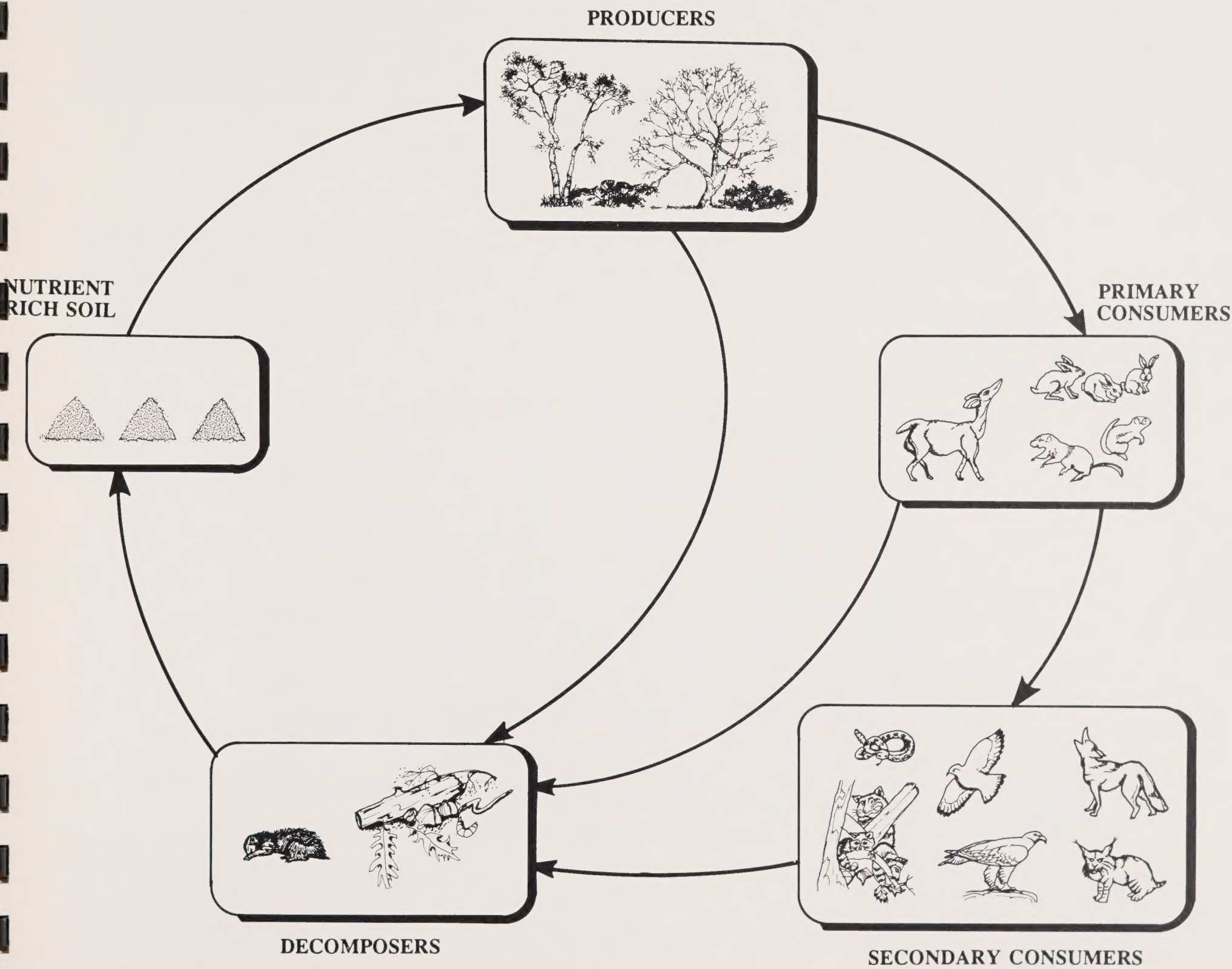
The potential homeowner looks for a healthy, productive and visually satisfying environment to surround his/her future home. Such environments are created and maintained by intricate natural cycles and energy flows, and it is the site designer's responsibility to understand these cycles, in order to design an environment which can satisfy city policy and, at the same time, appeal to potential buyers.

Two of the most important issues in southern California are the loss of vegetation and wildlife, and the problems with water. Development has a strong influence on both of these issues. The following demonstration models have been chosen to illustrate the important relationships between principles of ecological function and a development site. There are two models:

- Plant and Animal Model
- Hydrology Model

PLANT AND ANIMAL CYCLE

The plant and animal model depicts the cycle of producers (plants) to consumers (animals) to decomposers (microorganisms) and back to producers. If one element of the cycle is missing, problems are created for the rest of the cycle. Throughout Los Angeles, the native plant species that provide habitat for the animal populations have been greatly diminished. The smaller animals can still find protection, but the more specialized larger animals have retreated to safer territory. These larger predators play an important role in that they prey on the smaller animals, such as rodents, preventing them from becoming pests. A healthy plant and animal cycle could benefit not only the plant and animal communities, but the human community as well. People enjoy seeing wildlife and knowing it is present. If a habitat is provided along with proper management the system could be very beneficial.



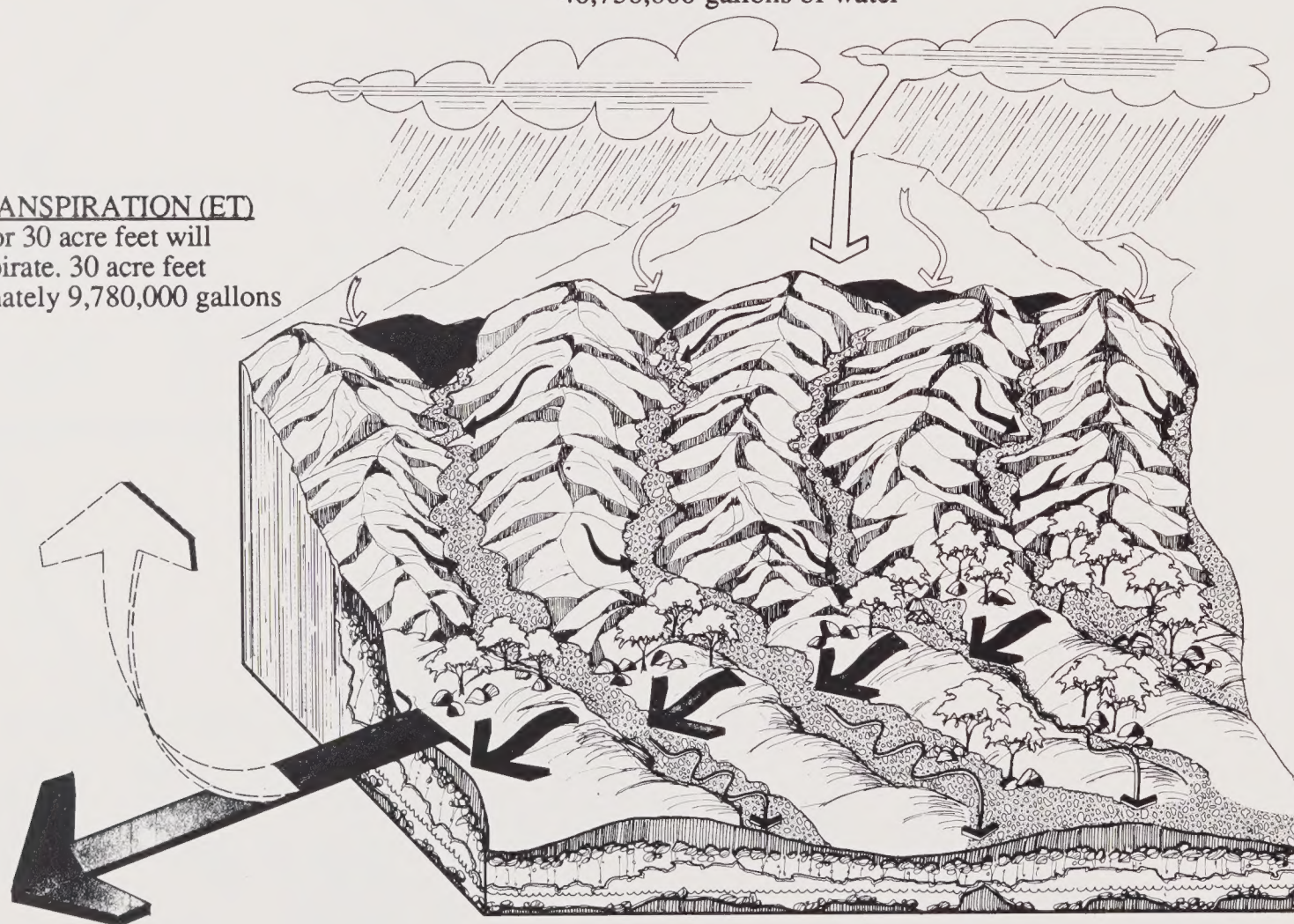
PLANT & ANIMAL MODEL

SCENARIO A 100 acre site in the Los Angeles hillsides experiences a natural water cycle of water infiltration, runoff and evapotranspiration from the area's limited rainfall.

AVAILABLE WATER 15 inches of rain precipitate to the site.
Over a 100 acre site 15 inches becomes 1,500 inches or 125 acre feet of water.
125 acre feet is approximately 40,750,000 gallons of water

EVAPOTRANSPIRATION (ET)

24 percent or 30 acre feet will evapotranspire. 30 acre feet is approximately 9,780,000 gallons of water.



RUNOFF 46 percent or 57.5 acre feet will runoff the property. 57.5 acre feet is approximately 18,745,000 gallons of water.

INFILTRATION 30 percent or 37.5 acre feet will infiltrate the ground. 37.5 acre feet is approximately 12,225,000 gallons of water.

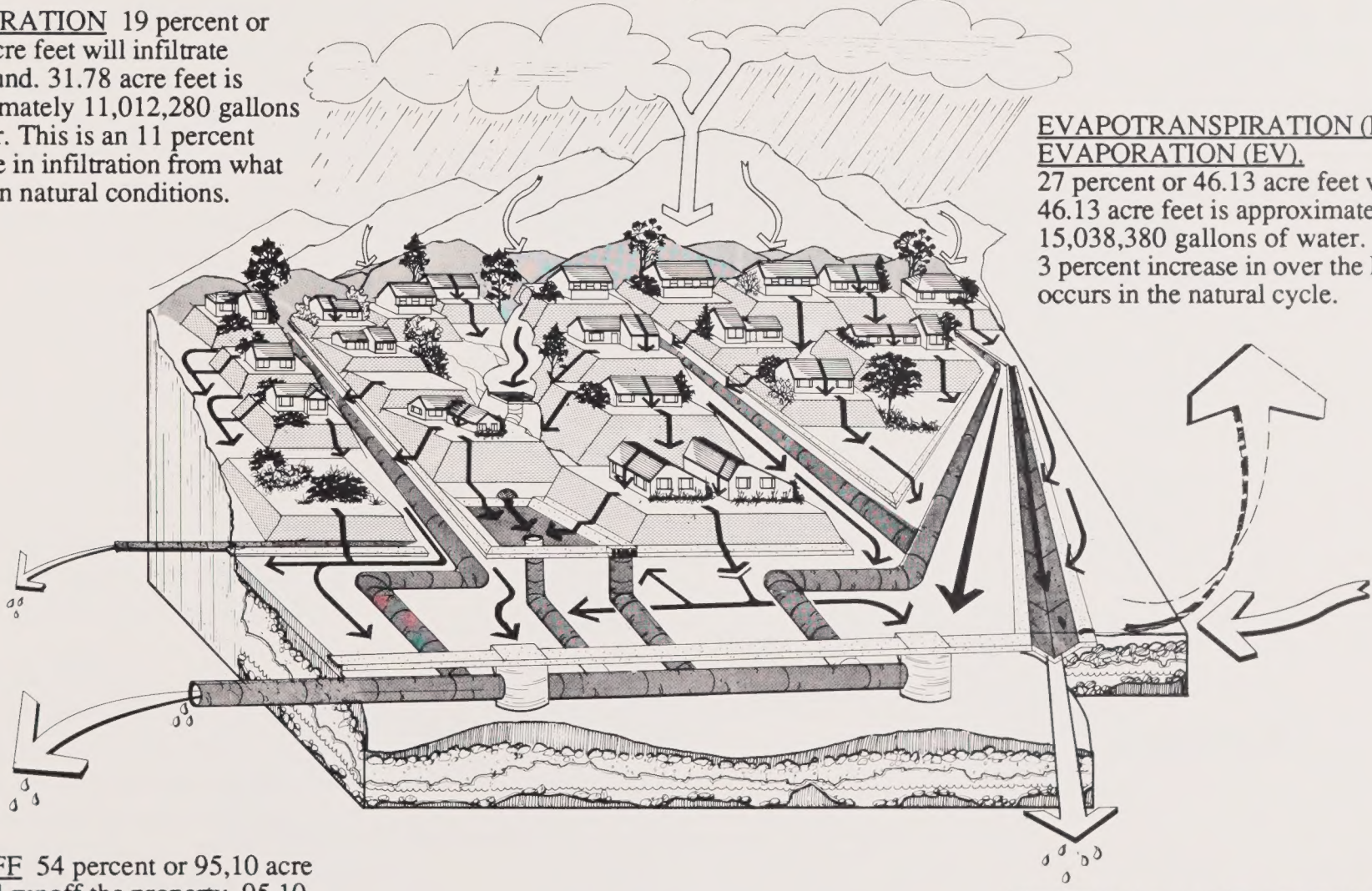
**WATER MODEL:
Natural Site--100 Acres**

SCENARIO A developer decides to build houses on the 100 acre site. His designs include 75 acres of developed space for houses and 25 acres natural open space. His plans specify 100 houses.

INFILTRATION 19 percent or 31.78 acre feet will infiltrate the ground. 31.78 acre feet is approximately 11,012,280 gallons of water. This is an 11 percent decrease in infiltration from what occurs in natural conditions.

AVAILABLE WATER 15 inches of rain precipitate to the site. Over a 100 acre site 15 inches becomes 1,500 inches or 125 acre feet of water. 125 acre feet is approximately 40,750,000 gallons of water.

EVAPOTRANSPIRATION (ET) and EVAPORATION (EV). 27 percent or 46.13 acre feet will EVET. 46.13 acre feet is approximately 15,038,380 gallons of water. This is a 3 percent increase in over the ET that occurs in the natural cycle.



RUNOFF 54 percent or 95.10 acre feet will runoff the property. 95.10 acre feet is approximately 31,002,6000 gallons of water. This is an 8 percent increase in runoff over what occurs in natural conditions. The money that could be saved by collecting the runoff water alone would be extremely beneficial to homeowners, and could be a selling point for the developer.

ADDITIONAL AVAILABLE WATER 50 acre feet, or 16,300,000 gallons of water are pumped to the site. Total amount of water available to the site is now 57 050,000 gallons.

**WATER MODEL:
Traditionally Developed Site--100 acres**

SCENARIO Another developer decides that he also wants to build houses on the site. He envisions clusters of houses that will fit in with the topography. He figures that if he puts at least four units per acre over 30 acres, he will build at least 120 units, and still have 70 acres as open space.

The developer conscious of the cost of water has designed permeable retention ponds, to capture the site's runoff. By using this captured water for irrigation, the development will import less water, and the homeowners will be able to save money.

AVAILABLE WATER 15 inches of rain precipitate to the site. Over a 100 acre site 15 inches becomes 1500 inches or 125 acre feet of water. 125 acre feet is approximately 40,750,000 gallons of water.

EVAPOTRANSPIRATION (ET) and EVAPORATION (EV). 32 percent or 59.06 acre feet will EVET. 59.06 acre feet is approximately 19,253,560 gallons of water. This is an 8 percent increase in over the ET rate that occurs in the natural cycle.



RUNOFF 101.31 acre feet will be available to runoff to the retention ponds. Of this 101.31 acre feet 30% will be lost to EV, infiltration and runoff, as not all the water can be captured. This leaves approximately 70 acre feet that can be recycled for irrigation and other out-of-doors purposes. As only 60 acre feet are needed there will be a balance of 10 acre feet.

INFILTRATION 24 percent or 43.89 acre feet will infiltrate the ground. 43.89 acre feet is approximately 14,308,140 gallons of water. This is a 6 percent decrease in infiltration from what occurs in natural conditions.

ADDITIONAL AVAILABLE WATER 60 acre feet, or 19,560,000 gallons of water are pumped to the site. Total amount of water available to the site is now 60,310,000 gallons.

WATER MODEL:
Alternatively Developed Site--100 acres.

COMPARISON OF SHORT TERM
VERSUS LONG TERM BENEFITS

The developer is concerned with the outlay of money necessary to build a project, but the marketability of the project is also a concern. The design guidelines suggested in the case study alternatives may require additional expenditures, but the developer can sell these houses for a higher price. Potential homeowners are likely to respond positively to the fact that their welfare has been carefully considered. The inclusion of the design guidelines, to be discussed later, will save the homeowner money in years to come. By using water saving techniques, water costs will be minimized. Information offered in the new Xeriscape ordinance could provide assistance. By employing certain landscaping and architectural elements, as well as orienting houses to receive maximum sun in the winter, and maximum shade in the summer, the homeowner will save money on heating and air conditioning bills. By offering these and other amenities the developer will increase the marketability of his project.

COST MODEL

A third demonstration model illustrates a means to relate short term expenditures with long term benefits and to show that long term savings can be realized through conscientious design. The cost model is concerned with three things:

- Cost of watering exotic plant materials versus native plant materials
- Maintenance costs for hardscape and softscape materials
- Cost of design over time

The cost model has not been filled in. It is an example of the concepts the developer can consider when designing his tentative

COST MODEL					
AREA	UNIT OF MEASUREMENT WHERE APPLICABLE	LOW RESIDENTIAL	MED. RESIDENTIAL	CLUSTER UNITS	TOTAL
NUMBER OF ACRES					
NUMBER OF UNITS					
OVER ALL BUILT SPACE					
OVER ALL OPEN SPACE					
LANDSCAPED AREAS					
NATIVE PLANT AREAS					
FRONT YARD SPACE					
BACK YARD SPACE					
HARDSCAPE					
DRIVEWAYS					
SIDEWALKS					
TRAILS					
ROADWAYS					
ACTIVE RECREATIONAL SPACE					
PARK SPACE					
HORSE KEEPING AREA					
LAND ON THE DOWNSLOPES THAT IS IN A RANGE OF 200' FROM HOUSING					
LANDSCAPING					
EXOTIC LANDSCAPE					
NATIVE LANDSCAPE					
AGRICULTURE (GROVE)					
NATURAL OPEN SPACE					
HARDSCAPE					
WATER USAGE					
WATER TO EXOTICS					
WATER TO NATIVES					
WATER LOST TO HARDSCAPE RUNOFF					
COSTS	CAPITAL COST	ANNUAL COST	CUMULATIVE COST FIRST TEN YEARS	CUMULATIVE & CAPITAL COSTS	
LANDSCAPING					
EXOTIC LANDSCAPE					
NATIVE LANDSCAPE					
AGRICULTURE (GROVE)					
NATURAL OPEN SPACE					
HARDSCAPE					
WATER USAGE					
WATER TO EXOTICS					
WATER TO NATIVES					
PERCENT OF WATER LOST TO TO HARDSCAPE RUNOFF					
RECYCLE SYSTEM					
WATER SAVED DUE TO RECYCLING					
LANDSCAPE MAINTENANCE					
MAINTENANCE FOR LAND ON THE DOWNSLOPES THAT IS IN A RANGE OF 200' FROM HOUSING					
GROVE MAINTENANCE					
GROVE PROFIT					
HARDSCAPE MAINTENANCE					

SITE INVENTORY

The Site Inventory is a means for describing a piece of land by organizing geographic information in specific categories. The categories generally considered as important for analysis include: hydrology, soil, slope, biology, geology, archaeology, visual considerations, microclimate and on and off site land use. Some situations may require additional categories of information. In most cases the inventory will include a map for each of these categories. These maps may be considered as a series of horizontal sections cut through the land.

While an inventory of each of these factors is vital to a proper site analysis not all resources have the same importance. For example, views play a major role in the siting of houses. The value of a house may be lessened if it has an unpleasant view, and avoidance of an unpleasant view may require re-orienting the house, or planting a visual buffer; but the soil and geological foundation the house sits on determines whether the house should be built at all. Therefore, soils and geological factors may be considered more important.

In this phase the land will be examined to determine what is happening on the site in terms of ecological systems. This is extremely important as it gives the developer a baseline from which to work in shaping a new development.

The Site Inventory forms the foundation base for a suitability model with determination of environmentally suitable land use derived from both the specific site information and general hillside information. The Site Inventory includes three steps:

- Opening Questions
- Inventory Questions
- Inventory Maps

The Opening Questions provide direction in determining what site inventory maps will be needed. They also determine if development is feasible at all. The Criteria questions help the developer know what to look for on the land. Inventory Maps are graphic representations of the information gathered. There is no judgement involved at this stage. Only facts will be presented.

OPENING QUESTIONS

It may not be necessary to prepare an analysis for each category. A simple questionnaire should help determine which analyses are most useful for each situation. The questionnaire asks pertinent questions about each resource. Any “yes” answer means that an inventory analysis for that resource must be prepared. The developer should be aware that a considerable number of “yes” answers might indicate that development should not take place.

- Are there any perennial streams on the property?
- Are there any natural springs on the property?
- Will storm runoff contribute to onsite flooding?
- Will storm runoff from the site contribute to offsite flooding?

YES	NO

If you answered YES to any of these questions,
Prepare a Site Hydrology Map!

- Does the property have slopes exceeding 20%

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If you answered YES to this question,
Prepare a Site Slope Map!

- Have landslides or slumping occurred on the property?
- Is erosion evident on the site?

If you answered YES to either of these questions,
Prepare a Site Soils Map!

- Are there any major rock outcroppings on the property?
- Are there any active or non-active faults on the property?
- Are there any active or non-active faults within a ten mile radius of the property?
- Does the property have a major ridgeline?

If you answered YES to any of these question,
Prepare a Site Geology Map!

- Are there any oak trees on the property?
- Are there any rare or endangered plant species on the property?
- Do rare or endangered animal species inhabit the property?

If you answered YES to any of these question,
Prepare a Site Biology Map!

- Are there any archeological or historical resources on the property?

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If you answered YES to this question,
Prepare a Site Archeological Map!

- Can the site be viewed from major offsite locations?
- Are the views offsite of scenic importance?

If you answered YES to either of these questions,
Prepare a Site Visual Considerations Map!

- Could there be energy savings from proper use of solar access?

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If you answered YES to this question,
Prepare a Site Microclimate Map!

- Is the land presently being used in any manner?
- Are there offsite landuses which enhance or detract from site values?

If you answered YES to either of these questions,
Prepare a Site Landuse Map!

INVENTORY QUESTIONS

For each inventory subject, there is a list of questions to help determine what information is needed. For some conditions, such as slope and general hydrology questions might be answered by owners or planners. Others may require information from experts in a particular discipline. Answers to the questions will establish the criteria for Site Inventory Maps and should be reflected in the maps. Shades and patterns define areas. Maps should be as simple as possible. A legend should be provided, but call outs are acceptable if they are better able to provide information.

The site inventory for the case study will be presented here to illustrate inventory methods.

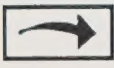
HYDROLOGY

The hydrology map describes the action of water on the site. Ephemeral (periodic) and perennial (constant) streams must be mapped as well as inflow and outflow of water on and off the property. Springs can be found by examining areas of lush vegetation. Wetlands, debris basins and floodplains must also be noted. The Inventory can be prepared from on-site study and from the topographic map for the site. In cases where larger drainage courses or streams run through the site, hydrologic data may be needed.

- What are the courses of perennial streams?
- Where are intermittent streams?
- In a storm, where does water enter the site?
- Are there natural springs and where are they located?
- Where does water pool on the site?
- Are there areas where flood levels are evident?
- Where is there evidence of debris being carried through the site?
- Where are there areas which could be considered wetlands?
- If there is water on the site, what is the visual appeal?
- Where are there areas available for water retention ponds?



HYDROLOGY ANALYSIS

 NATURAL DRAINAGE CHANNEL



SITE DESIGN
FOR HILLSIDE
DEVELOPMENT

SITE INVENTORY

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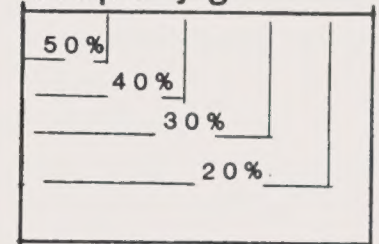
SLOPE

The slope analysis is best made using a 1"=200' scale topographic map obtainable from the city. Slopes under 10%, over 30% and over 50 % should be defined. For sites with more varied topography, it is useful to make fewer distinctions. Slope percentages for the slope analysis are calculated by using the formula $G=D/L$; where G stands for the slope gradient, D stands for the vertical distance, and L stands for the horizontal distance. The scale and contour interval of the map determine numbers for the formula.

Since the vertical distance and the gradients are known, the horizontal distances must be calculated. Dividing D by G gives L, therefore, a 50% plus gradient is 100 feet long or less, a 40-50% gradient is 100-125 feet long, a 30-40% gradient is 125-167 feet long, a 20-30% gradient is 167-250 feet long, and a gradient less than 20% is more than 250 feet long. The distances can be drawn on a Slope Jig which can be slid along 50 foot contour intervals perpendicular to the slope. Where the contour distance is between 125 and 166.67 feet, there is a 30-40% gradient. By moving the jig along the entire topographic map, it is possible to calculate the slope percentages for the property. From this a slope range is found.

- Where are slopes less than 10%?
- Where are slopes exceeding 30%?
- Where are slopes exceeding 50%?
- Where do steep opposing slopes meet to indicate possible riparian areas?

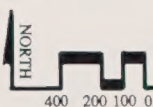
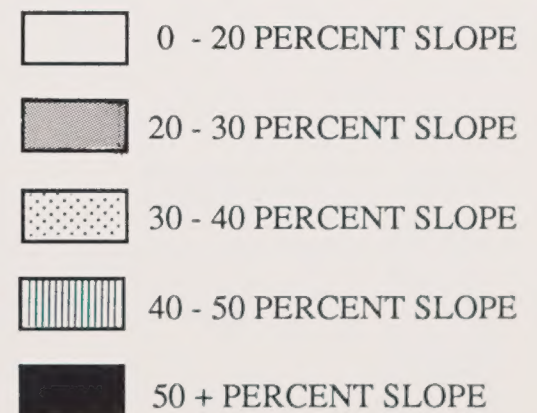
slope jig



SITE DESIGN
FOR HILLSIDE
DEVELOPMENT

SITE INVENTORY

SLOPE ANALYSIS



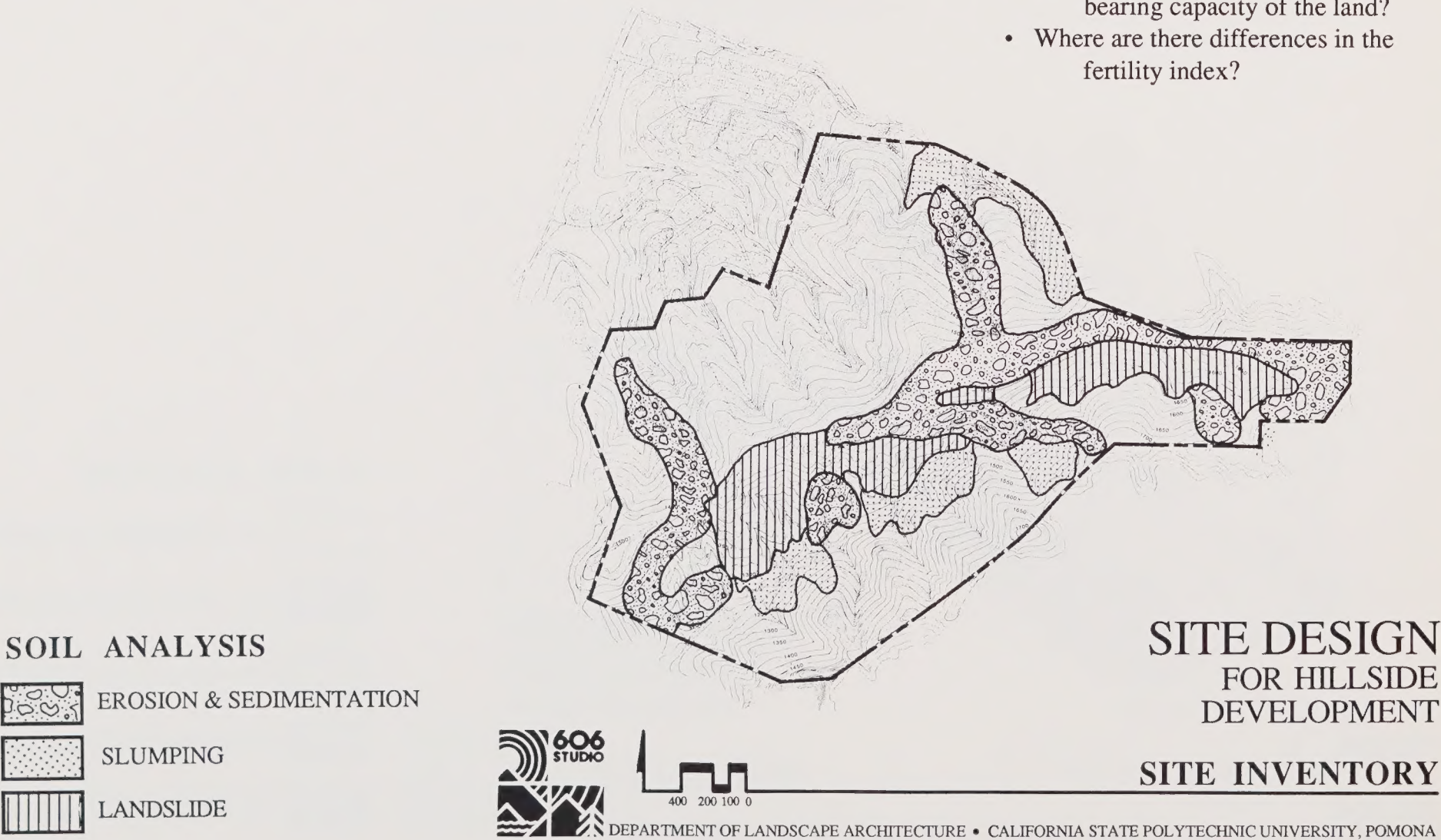
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SOIL

Existing soils information for sites in Los Angeles is hard to find, and it is necessary to have a qualified soil analyst prepare a report. This is required by the city. It is usually best to map soils according to U.S. Soil Conservation Service (SCS) categories and apply interpretations, which are available

from SCS. This information will help identify areas of high erodibility, shrink-swell potential, permeability and potential landslides or slumping. It is important to address these factors in order to provide safe foundations. Well used trails might indicate heavy use that could compact the soil. Mud flow from higher elevations onto the property or to the adjacent land and other potential problems might be predicted and minimized.

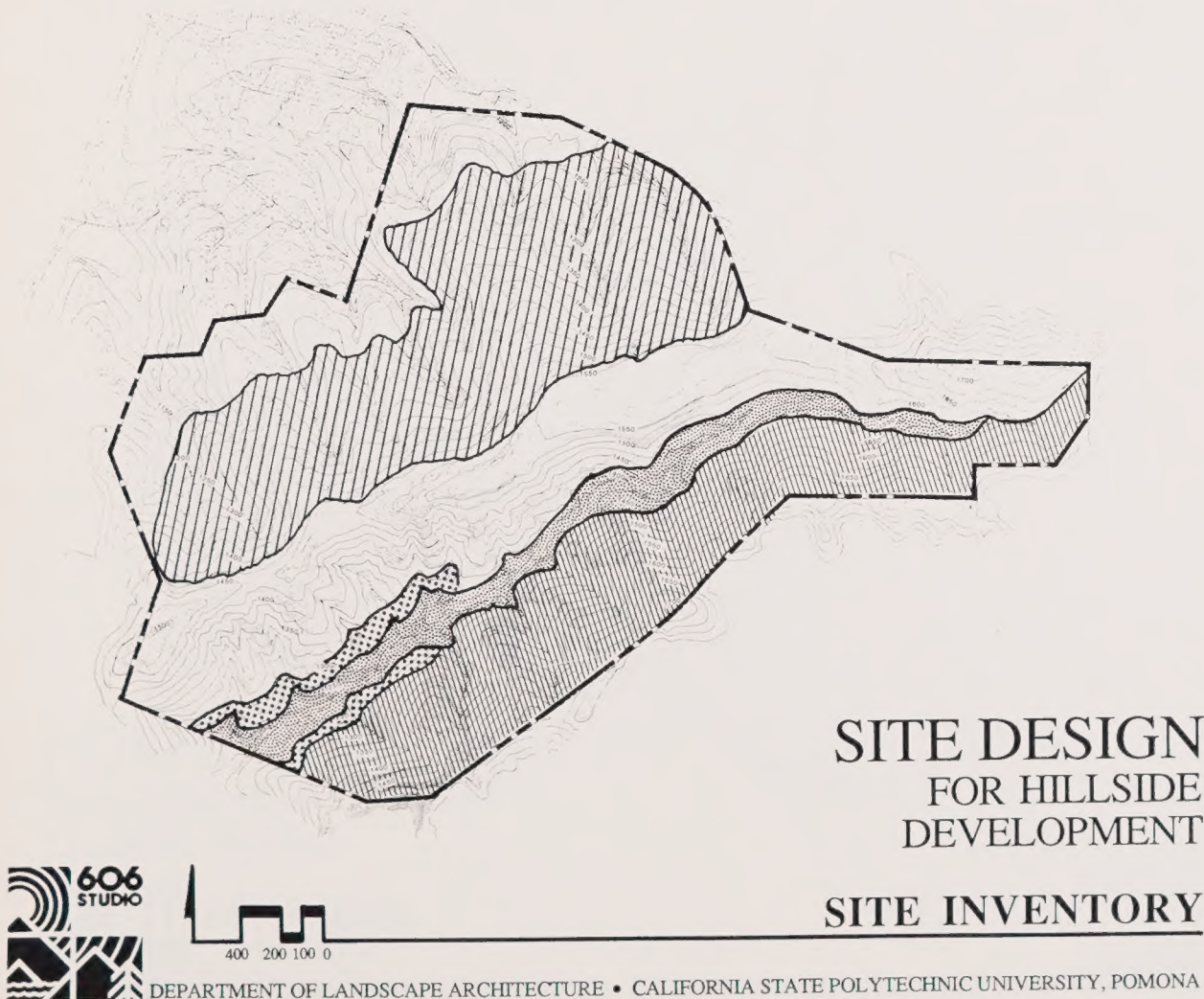
- Is slope failure evident on the site?
- Is there soil conducive to landslides on the site?
- Where can slumping land be found?
- Where is there indication of soil erosion?
- Where is sedimentation evident?
- Are there areas where cracked ground shows evidence of a shrink-swell cycle?
- Where are there indications of high water table?
- Is there evidence of soil compaction from prior land use?
- Where are there problems with the bearing capacity of the land?
- Where are there differences in the fertility index?



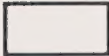
BIOLOGY

These maps are concerned with plants and animals on the property. Plant communities, important specimens, animal habitats and trails should be mapped. Information can be prepared by on site survey or by consulting the Natural Diversity Data Base or a biologist.

- Where are areas of lush vegetation that suggest vital plant and animal communities?
- What plant communities exist on the site and what is their extent?
- Are there any rare or endangered plant and animal species found on the property? Where are they located?
- What are the dominant animal species?
- What are the dominant plant species?
- What pathways are formed by animals and where do they lead?
- Is there evidence that the land has been grazed?
- Are there continuous patterns of plant material on site? How could these patterns be retained?
- Locate all oak trees.
- Are there riparian communities to be found on the site? What plants are found in them?
- Are there wetlands on the property?



BIOLOGY ANALYSIS

-  LIGHT VEGETATION
-  MEDIUM VEGETATION
-  DENSE VEGETATION
-  RIPARIAN AREA
-  OAK TREES

GEOLOGY

Geological information can be obtained from a site survey and the United States Geological Survey. On site, the natural resources and the physical features of the land are observed. Earthquake fault information can be obtained from the city. Faults should be precisely located as they will be subject to codes established by the City Engineer.

- Have mineral resources been documented in the area?
Could there be resources on the site?
- What geologic features can be seen?
- Where are there large groups of rock outcropping that must be considered for design purposes?
- Is there evidence of faulting on the land?
- Where are there faults within a 10 miles radius of the site

ARCHAEOLOGY

Archaeological analysis requires a study by a qualified archaeologist. If any evidence of archaeological remains is found on the property such an analysis will define their extent and mark the limits of the areas which must be preserved.

In the case study there was no evidence of any archaeological remains.

GEOLOGICAL ANALYSIS

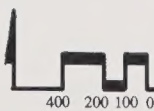
 RIDGE LINE

 ROCK OUTCROPPING



SITE DESIGN
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VISUAL

This map concerns views, including views of the development from off the site, views outward by those living on the property, and views of the land from within. Visible areas and areas from which views occur are usually mapped. Quality or desirability of views is usually also assessed.

- Which off site views would add to the value of the houses on the site?
- Which off site views (such as power plants) will be less pleasing to a homeowner?
- Which areas would be provide exceptional night time views? (lights of the city)
- Are there ways in which good views could become blocked?
- Are there ways to block unpleasant views?
- Which views on the site could be enhanced?

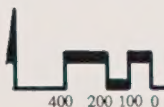


SITE DESIGN FOR HILLSIDE DEVELOPMENT

SITE INVENTORY

VISUAL ANALYSIS

- MAJOR VIEWS FROM OFF-SITE
- MAJOR FOCAL POINTS FROM OFF-SITE & ON-SITE



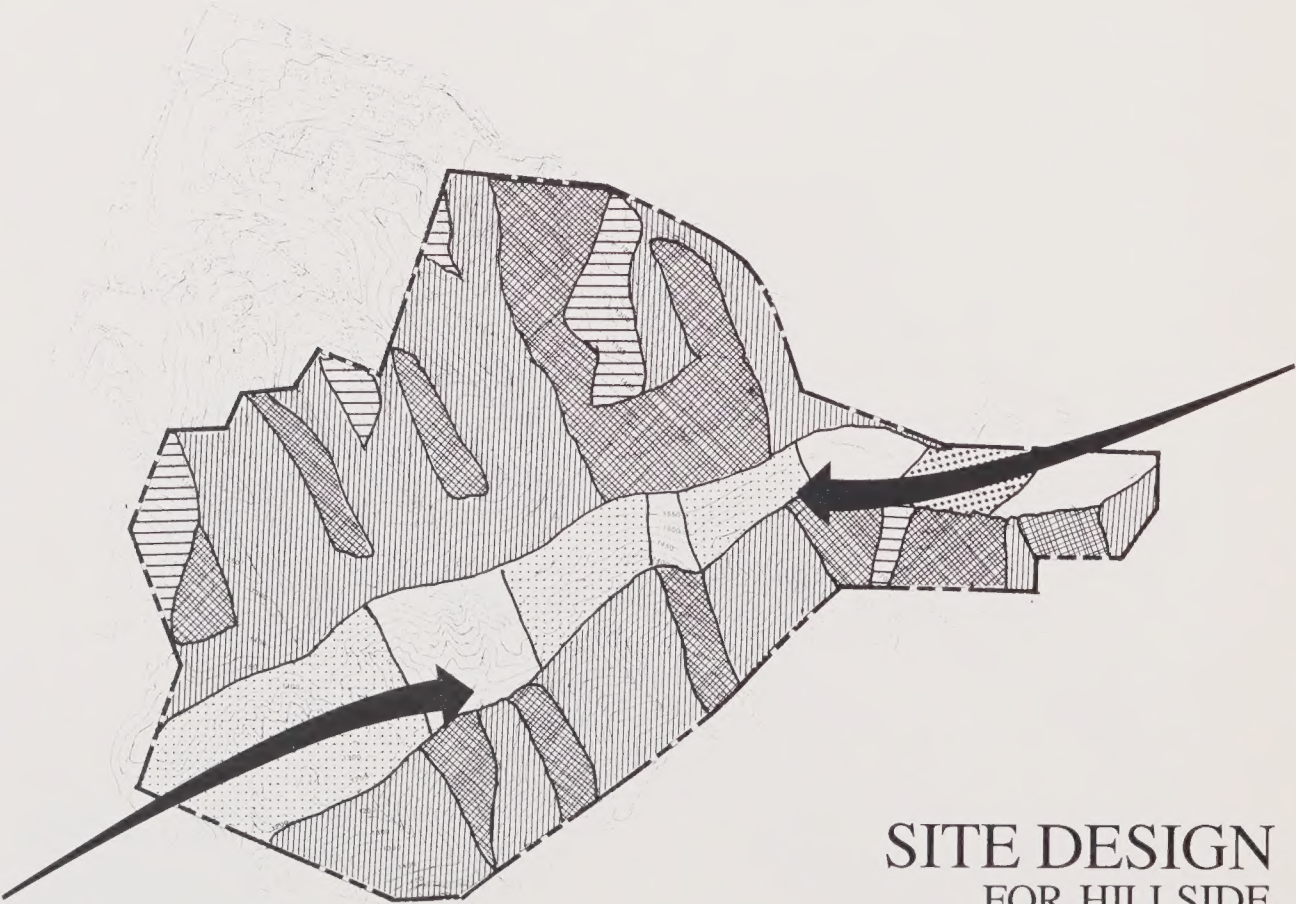
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MICROCLIMATE

This map helps to discern the areas of maximum and minimum solar radiation gain and will be of special assistance during the design phase. Other specific microclimatic conditions that might affect site design should also be mapped. Since microclimate data is rarely available, information is usually gathered through the design teams direct experiences and by consulting others who have experience with the site.

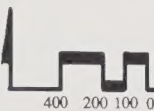
- Which areas have the best solar access?
- What proportion of the land has:
 - northern exposure?
 - southern exposure?
 - eastern exposure?
 - western exposure?
- What are the prevailing patterns of air movement?
- How would Santa Ana winds affect the site?
- In which areas do gusty winds occur?
- Are there any particular unusual conditions that exist on the site,

MICROCLIMATE ANALYSIS



SITE DESIGN
FOR HILLSIDE
DEVELOPMENT

SITE INVENTORY



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ON AND OFF SITE LAND USE

By determining uses taking place adjacent to the property a design can better mesh with the character of the area. An understanding of existing on-site land use can help to determine the potential uses or environmental needs to be addressed. Evidence of burning, for example, would indicate that vegetation is temporarily in a non-natural state. Grazing allows the introduction of non-native grasses and often destroys native trees and shrubs. Cattle trails contribute to erosion and compaction problems. Prior grading

changes the character of the natural landscape, and should be looked at carefully to make sure that natural systems are not overlooked. Compaction of soil or loss of soil through prior use could have impacts on the success of vegetation in the future. It also could affect future erosion and slippage.

- Where are existing hiking, biking or equestrian trails?
- Will these be assets to the new development?
- Are there nearby parks which would be attractive to the new development?
- Are there physical features of the site that could affect future use, such as old wells? Where are they located?
- How does the proposed land use relate to the surrounding land use?
- Can the transportation system support additional development?
- What utilities exist on or near the site (gas, electric or telephone lines, water treatment plants, dumps, power stations)?
- Has the land been disturbed by
 - a. recreational use?
 - b. fire?
 - c. grazing?
 - d. prior grading?
 - e. loss of soil?
- What effects of prior disturbance could have bearing on development?



SITE DESIGN FOR HILLSIDE DEVELOPMENT

SITE INVENTORY

LAND USE ANALYSIS

- ... TRAILS: HIKING & EQUESTRIAN
- FIRE ROAD
- /// DISTURBED LAND AREA



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SUITABILITY

Suitability is a measure of the capacity of the land for supporting specific human uses. Each of the questions described in the site inventory contributes in some way to determining the land’s suitability for a given use. Suitable attributes are those which support or make possible the development qualities listed on page 10. The three principal land uses most commonly under consideration in Los Angeles hillside area are housing, recreation and preservation.

The suitability analysis portion of the environmental site design process includes:

Suitability Criteria—establishes levels of suitability for specific site attributes for given land uses.

Site Inventory Checklist—lists significant natural attributes of a developer’s particular site.

Rules of Combination—establishes priorities and means for determining aggregate suitability based on determinations in the matrix

Suitability Model—applies the rules of combination to assess the level of suitability for the given use of each area of the site.

In the suitability analysis we move from the factual information in the site inventory through a series of informed judgements to an aggregation of judgements, which forms a pattern of relative suitability reflecting the land’s character and situation. This pattern then becomes a basis for design.

LAND USE		NATURAL CONDITIONS																		
		HYDROLOGY				SLOPE					SOIL					GEOLOGY				
HOUSING		NATURAL DRAINAGE CHANNEL				0 - 20%					EROSION FACTOR					IGNEOUS BEDROCK				
SINGLE FAMILY		PERENNIAL STREAM				20 - 30%					SHRINK-SWELL POTENTIAL					METAMORPHIC BEDROCK				
CLUSTERED		PONDED AREA				30 - 40%					PERMEABILITY					SEDIMENTARY BEDROCK				
TIERED		FLOOD PLAIN				40 - 50%					LANDSLIDES					ROCK OUTCROPPING				
		WETLAND				50% +					SLUMPING					ACTIVE FAULT ZONE				
RECREATION																INACTIVE FAULT ZONE				
ACTIVE																RIDGELINES				
PASSIVE																				
EQUESTRIAN TRAIL																				
PRESERVATION																				

SUITABILITY MATRIX

The tool used for recording suitability criteria is the Suitability Matrix which shows the potential interactions of natural conditions and various land uses. It demonstrates the relationships between the environmental concerns and the proposed land uses. A matrix is a graphic way of managing large amount of information in a compact space. The matrix shown here organizes the suitability assessment process by using symbols to show which site resources and land uses are most compatible. It relates to hillside property

in general and will be referred to throughout the process. This is a step that deals with relationships. Judgements are made at this stage. The land uses usually considered and analyzed for hillside development include:

Residential; three distinct patterns for hillside development are:

- Standard — single family lots spread throughout the site on various sized lots
- Clustered— dwelling units in

small groups to fit into the topography— approximately 6-20 units per acre within the cluster area— single family or higher density

- Terraced— buildings stepping down in a tightly packed arrangement

Recreational; three types of recreation possible for hillside development are:

- Active — pools, tennis courts equestrian centers, ball diamonds
- Passive—picnic areas, view spots
- Trails—hiking, equestrian, bicycle

Nature Preservation and Enhancement;

Preserving the land in a natural state or enhancing the natural features

The matrix includes conditions found throughout the southern California hillsides and can be used to compare these land uses with site conditions commonly encountered. These conditions correspond to the categories used for the site inventory.

It is possible that conflicts and contradictions may arise in this matrix. Attributes deemed unsuitable may exist in the same location as attributes deemed highly suitable. For this reason the matrix does not translate directly into a suitability map. Contradictions must first be resolved. A process for resolution will be addressed in the next section.

BIOLOGY																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																				
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SITE CHECKLIST

Using the Site Checklist the developer can move from the general to the specific as he notes the conditions relevant to his particular site. This narrows the focus as the designer contemplates the unique features of the site.

RULES OF COMBINATION

A central purpose of the environmental site design process is to ensure that the plan will be environmentally suitable. The developer and his consultants apply their own judgement, subject to review by permitting agencies. If the reviewers can understand the rationale behind decisions and their basis in environmental concerns, they have a common ground for discussion with the developer and are more likely to look favorably upon the plan. To accomplish this it is important that priorities be assigned to the conditions found on the site.

SITE CHECK LIST	
HYDROLOGY	
☐	NATURAL DRAINAGE CHANNEL
☐	PERENNIAL STREAM
☐	PONDED AREA
☐	FLOOD PLAIN
☐	WETLAND
SLOPE	
☐	0 - 20%
☐	20 - 30%
☐	30 - 40%
☐	40 - 50%
☐	50% +
SOIL	
☐	EROSION FACTOR
☐	SHRINK-SWELL POTENTIAL
☐	PERMEABILITY
☐	LANDSLIDES
☐	SLUMPING
GEOLOGY	
☐	IGNEOUS BEDROCK
☐	METAMORPHIC BEDROCK
☐	SEDIMENTARY BEDROCK
☐	ROCK OUTCROPPING
☐	ACTIVE FAULT ZONE
☐	INACTIVE FAULT ZONE
☐	RIDGELINES
BIOLOGY	
☐	OAK TREES
☐	SIGNIFICANT RIPARIAN VEGETATION
☐	SIGNIFICANT WILDLIFE HABITAT
☐	ENDANGERED SPECIES
☐	RARE SPECIES
ARCHAEOLOGY	
☐	ARCHAEOLOGICAL EVIDENCE
VIEWS	
☐	SIGNIFICANT VIEWSHED
☐	NIGHT VIEWS
☐	ON SITE VIEWS
☐	VIEWS FROM OFF SITE
MICROCLIMATE	
☐	NORTH FACING SLOPE
☐	SOUTH FACING SLOPE
☐	EAST FACING SLOPE
☐	WEST FACING SLOPE
☐	SANTA ANA WINDS
☐	GUSTY WINDS

The following steps outline this process:

I. LIST CONDITIONS DEEMED UNSUITABLE IN THE MATRIX

This list can come directly from the Site Checklist. Occasionally an important condition may occur on site which has not been revealed by the checklist. This should be added to the list.

II. RANK ATTRIBUTES AS TO IMPORTANCE

1. EXCLUSIONARY—deals with mandated conditions. This includes not only earthquake faults and endangered species but also land use restrictions such as building near power lines.
2. PRIMARY—contains natural attributes of extreme environmental importance. Major drainage systems, natural springs, prime vegetation stands, and steep slopes are all examples.
3. SECONDARY—contains conditions that are less important such as perennial streams and eroded areas, views, and solar access.

III. INSTITUTE "RULES OF COMBINATION" (Eliminate limiting factors by stages)

Areas with no exclusionary or primary conditions and fewer than three secondary conditions are considered suitable for development.

Possible development may occur through mitigation in areas having:

One Primary Condition, or
Three or less Secondary Conditions

Any development that takes place on land with primary or secondary conditions should include mitigation measures addressed to those conditions. See the Design Guidelines.

No development can take place when the following conditions occur:

One Exclusionary Condition
Two Primary Conditions
One Primary and two Secondary Conditions
Four Secondary Conditions

IV. SUITABILITY MODEL

Areas with specific conditions are easily defined by overlaying inventory maps to make a single composite map. A legend should be made using letters to list all conditions. Identify these conditions on the map. As areas of the map are marked add the letter corresponding to the appropriate condition. Cross hatch any areas which may not be developed.

Sometimes it will be found that conditions do not overlap but are in close proximity. A stand of riparian trees adjacent

to a stream and the stream will not overlap if the rules are strictly adhered to. However, they should be considered as overlapping because of their influence on each other. The developer will use his judgement to determine such areas where conditions overlap.

The information then constitutes a suitability map. This map will show three levels of suitability — Suitable Land, Unsuitable Land and Land Which Can Be Mitigated as shown in a legend. This procedure has been concerned with residential development.

In the case study there are no exclusionary considerations. The Primary Considerations are

Slope over 50% (in increments greater than 1 acre)

Riparian areas

Primary drainage area

Ridgelines

Oak trees

Specimen Oaks or important groupings of Oaks

Significant focal points

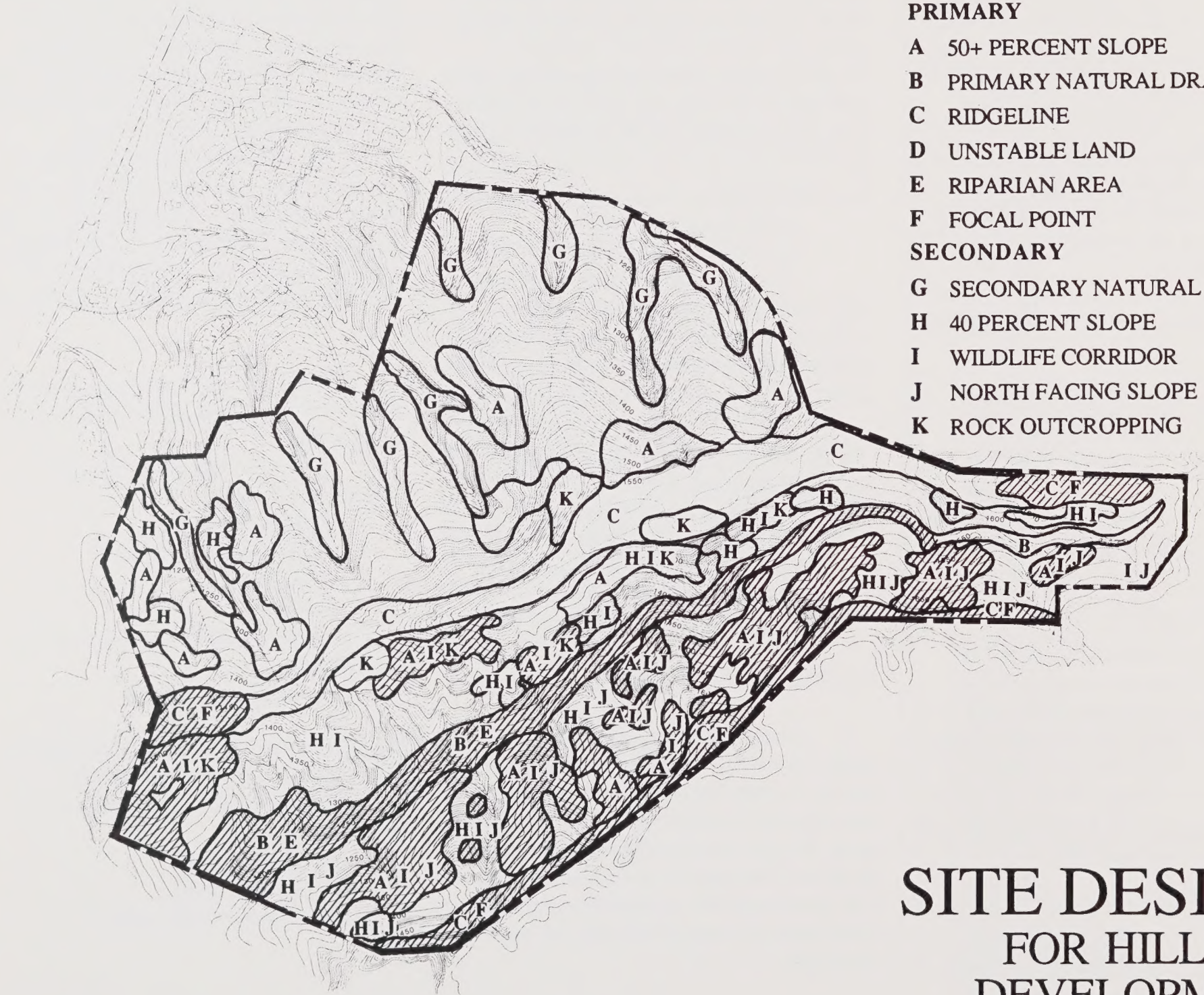
The Secondary Considerations (having less importance but still notable) include:

Drainage areas other than the primary one

Slopes of 40-50%

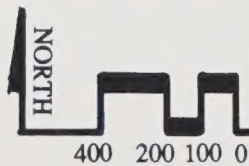
Rock Outcroppings

Significant wildlife habitats

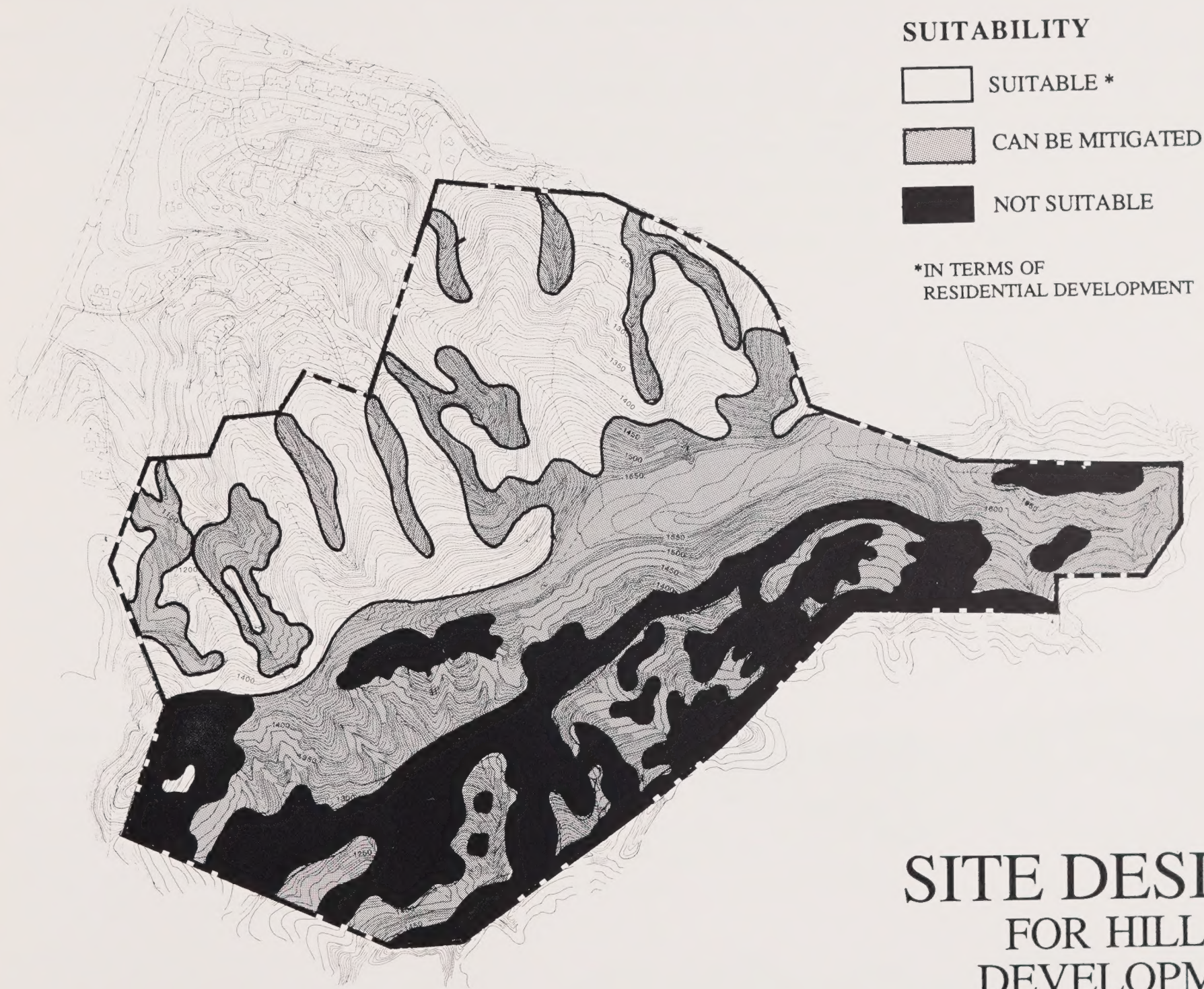


SITE DESIGN FOR HILLSIDE DEVELOPMENT

CONDITIONS MAP



DEPARTMENT OF LANDSCAPE ARCHITECTURE • CALIFORNIA STATE POLYTECHNIC UNIVERSITY, POMONA



SITE DESIGN
FOR HILLSIDE
DEVELOPMENT
SUITABILITY MAP



DEPARTMENT OF LANDSCAPE ARCHITECTURE • CALIFORNIA STATE POLYTECHNIC UNIVERSITY, POMONA

DESIGN GUIDELINES

Design criteria provide a means to apply the understanding of the particular site expressed in the suitability model and the suitability checklist, and lead to alternatives for land design. The guidelines suggest alternate ways to shape the elements of a plan. Subject matter of the guidelines includes :

- Preservation of Natural Character
- Grading
- Drainage and Erosion
- Siting of Houses
- Streets
- Parking
- Trails and Sidewalks
- Vegetation
- Fire Prevention
- Architecture

It is an extensive segment which will be illustrated for greater clarity. Broad guidelines cover certain facets of the development. These are followed by more focused, practical ways to mitigate problems and find solutions. When possible, the means are shown graphically by comparing acceptable and unacceptable solutions. This portion of the project provides a guide to environmental design concepts.

Preservation of Natural Character

The scenic qualities of hillside areas should be enhanced and preserved by encouraging the maximum retention of natural features. These include:

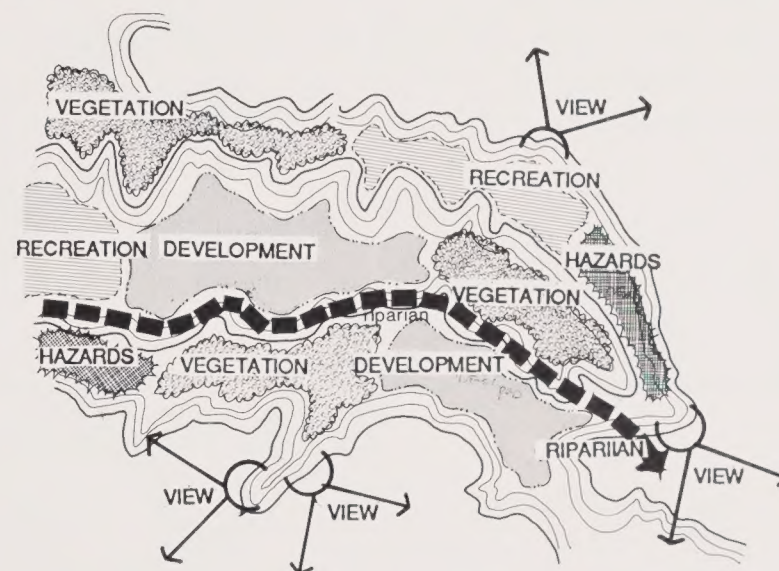
- A. Ridgelines, hilltops, finger canyons, rock outcroppings and other significant land forms.
- B. Stream, creek beds and other drainage courses.
- C. Wildlife habitats: undisturbed areas of food, water, shelter and cover
- D. Oak trees, woodlands and other significant natural vegetation.

- Adopt a comprehensive management plan for undeveloped land with adequate provisions for control, operation and maintenance.

- Consider carefully the implications of ridgeline development. They should be developed only when development enhances the natural qualities.

- Blend and adapt development to the natural topography and preserve native vegetation as much as possible. Enhance and do not obscure, detract from, or negatively affect the scenic quality of hillside areas. This might be accomplished by encouraging variety in site design, grading techniques, building types, and spacing of buildings.

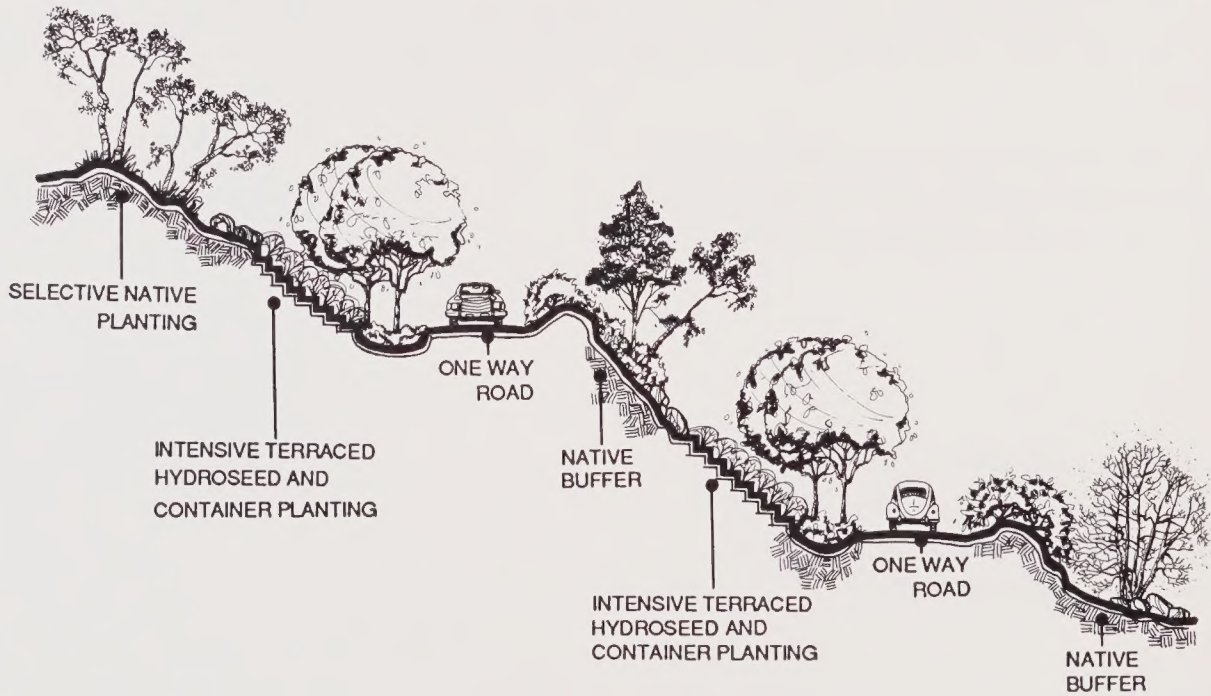
- Use natural building materials and colors that blend with the natural landscape. Landscape screening and setbacks should be used to minimize visual impacts.



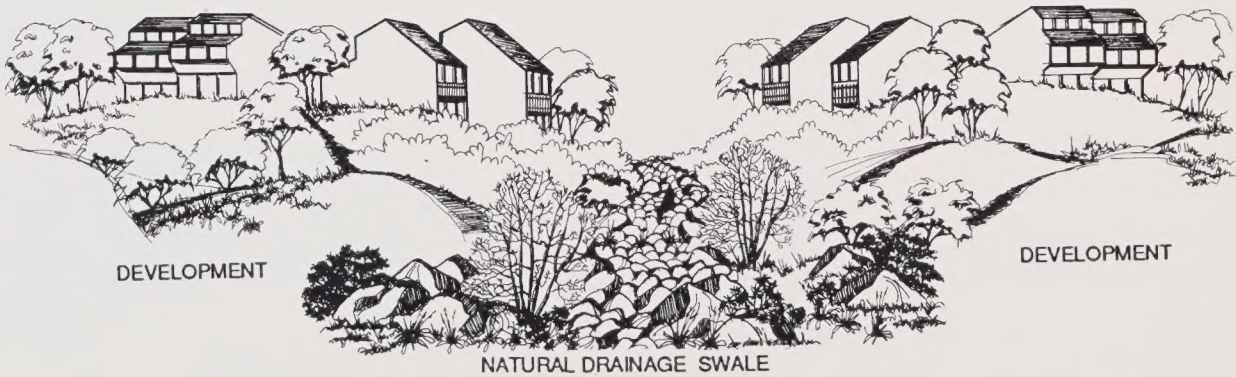
Landform Grading

Grading in hillside areas should be minimized and natural topography should be maintained to the greatest extent possible. When the natural topography must be altered, landform grading is a contour grading method for creating artificial slopes to simulate the appearance of natural terrain. This method of grading is thoroughly described in the booklet LANDFORM GRADING published for the City of Los Angeles Planning Department.

- Minimize grading for roads, streets, and storm drains while still conforming to public health and safety regulations and applicable engineering requirements.



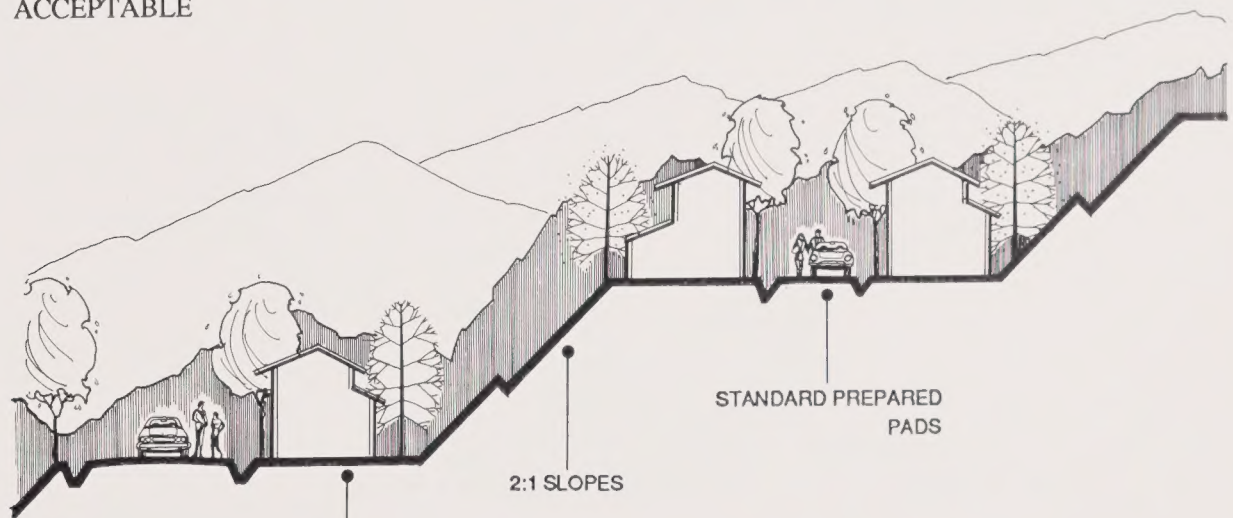
- Use natural drainage swales where possible. This will require limiting runoff to that which would naturally occur.



- Limit grading to that which is necessary for the primary use of each lot. Standard prepared pads resulting in grading outside of the building footprint and driveway area shall be discouraged.

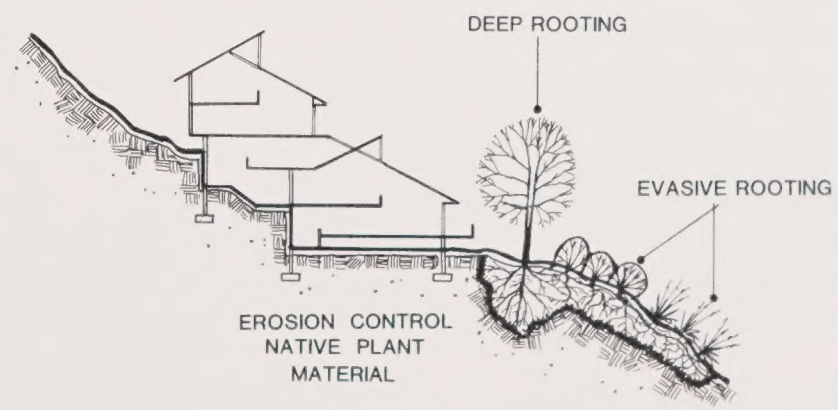


ACCEPTABLE

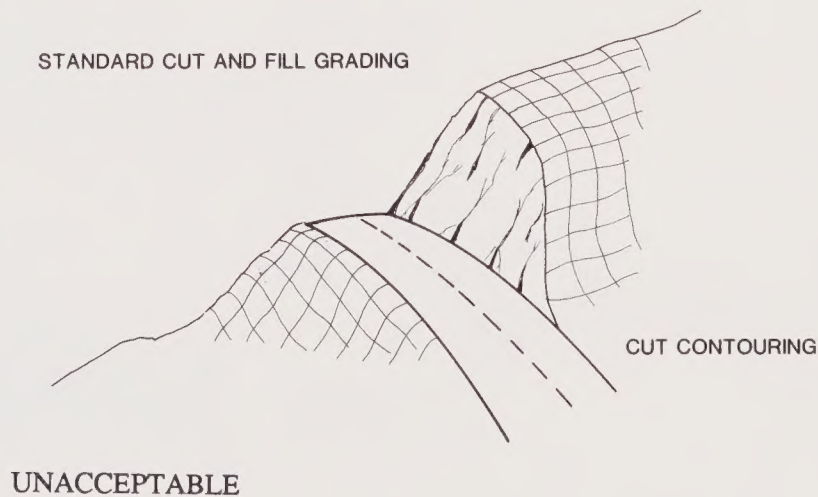
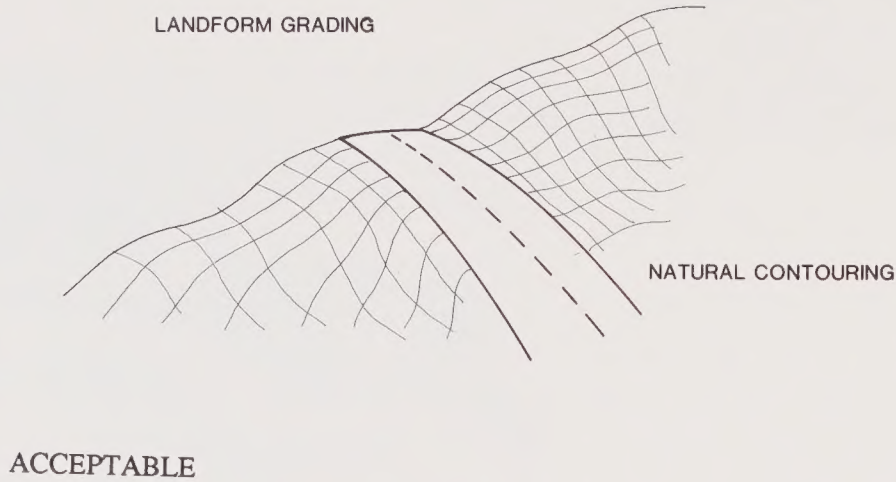


UNACCEPTABLE

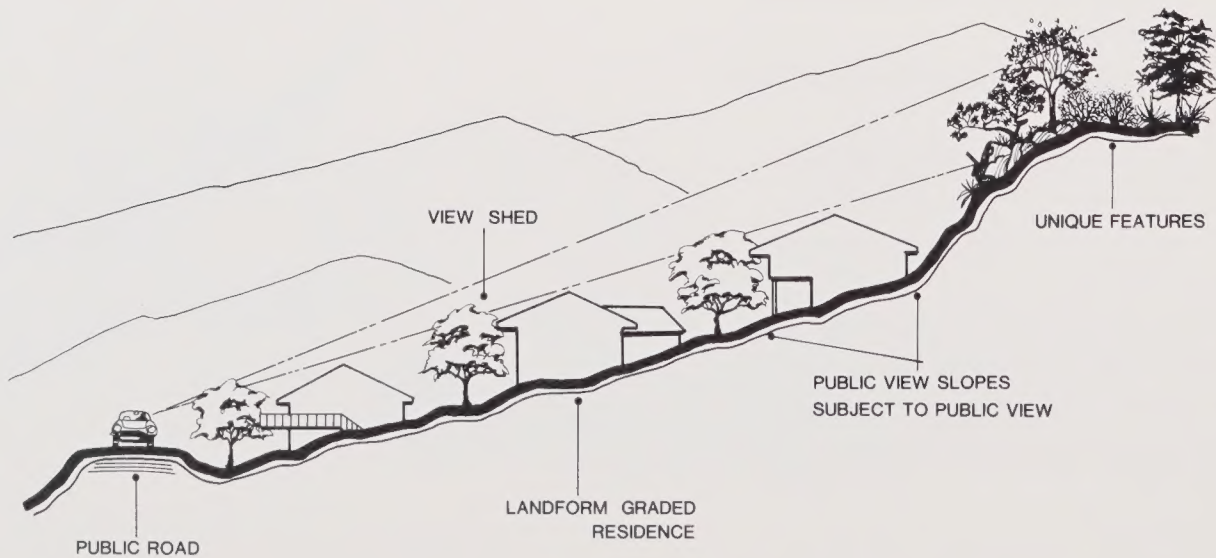
- Retain trees and other native vegetation on highly erodible soils to:
 - a. stabilize hillsides in areas of 25% or greater slope
 - b. retain moisture especially in major drainage ways.
 - c. reduce erosion, siltation, and nutrient runoff
 - d. preserve the natural scenic qualities of the area.
- Plant or otherwise protect all manufactured slopes, other than those constructed in rock, from the effects of storm runoff erosion within 30 days of the completion of final grading.



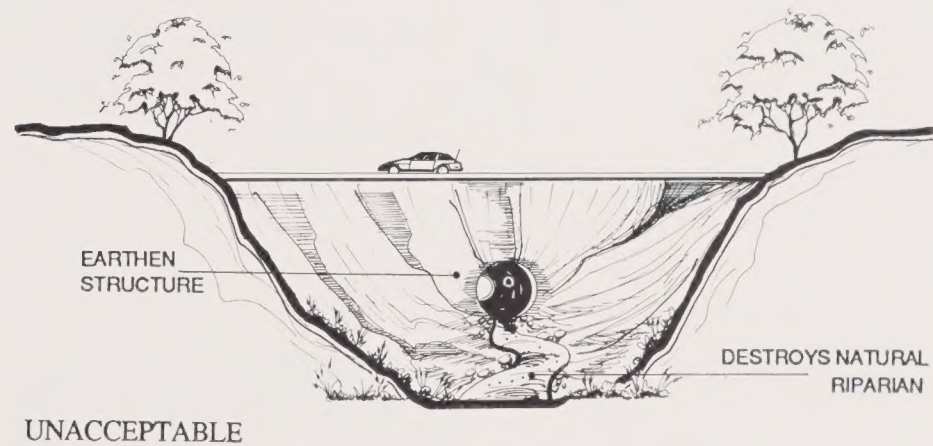
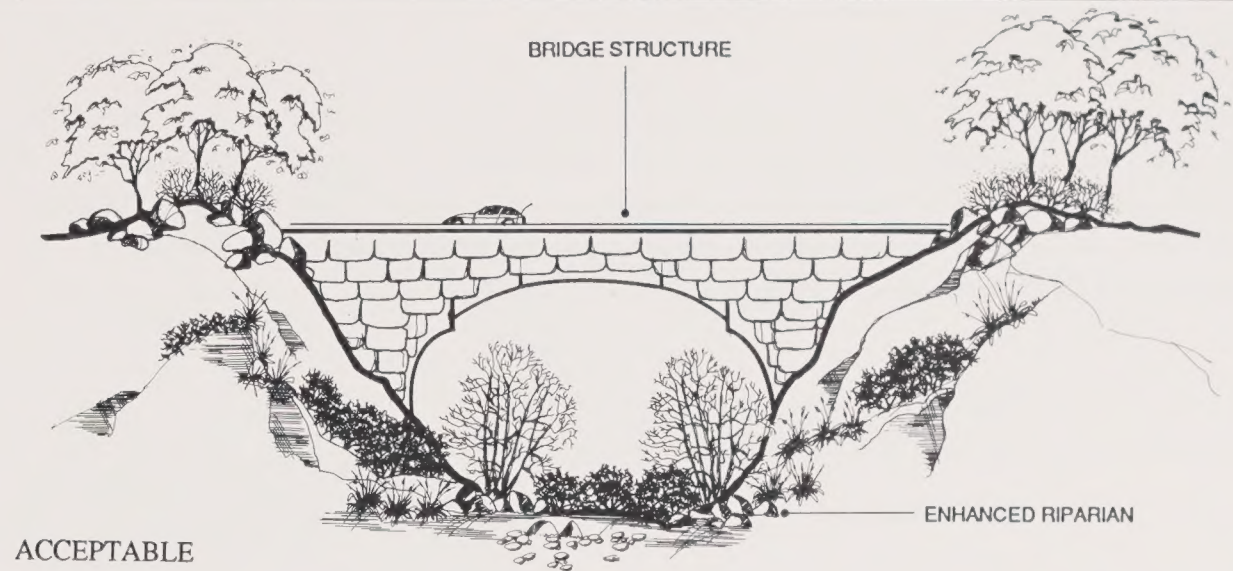
- Curve the toe and top of the slope in a concave or convex manner, respectively.
- Curve contours to blend with the natural slope. Avoid abrupt angular intersections.
- Match or blend required grading with the natural contours of adjacent terrain by avoiding abrupt changes in grade and by rounding off sharp angles at the top, toe and side of all cut and fill slopes.
- Avoid straight engineered slopes. Reflect as closely as possible the forms and shapes of the natural topography in cut and fill slopes.



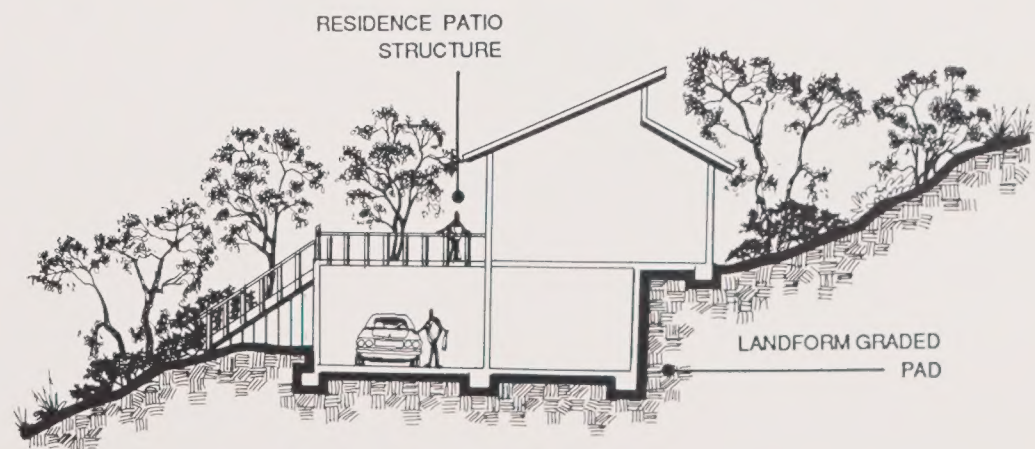
- Use landform grading when grading is necessary, but especially:
 - a. on slopes adjacent to scenic corridors as well as major and secondary highways
 - b. on slopes subject to public view
 - c. on slopes adjacent to undeveloped areas
 - d. on slopes internal to the project which may be significant to public view.
- Remove topsoil to an average depth of 6" before grading. Retain on-site. Replace soil after grading.



- Use bridges to cross canyons instead of making earthen structures.



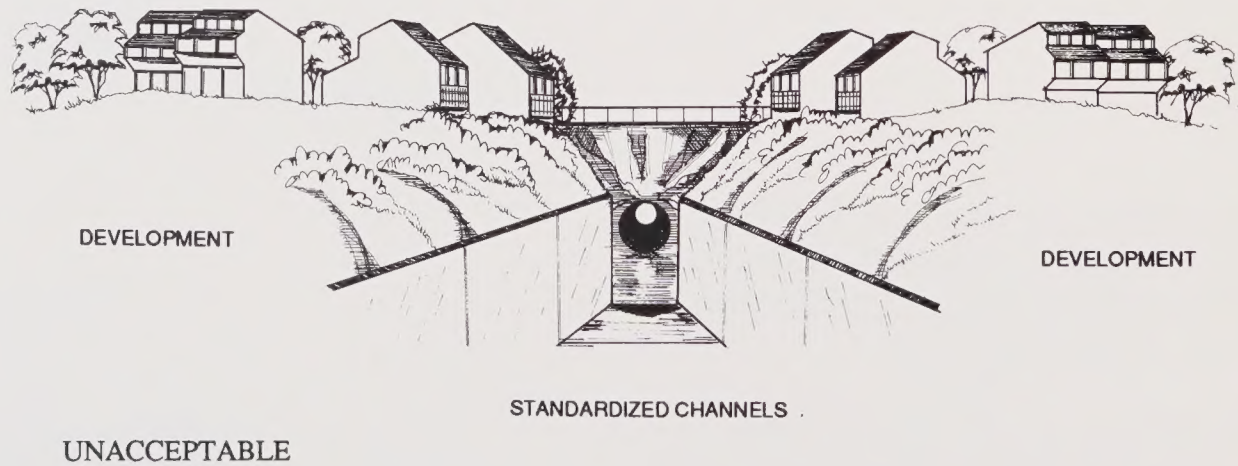
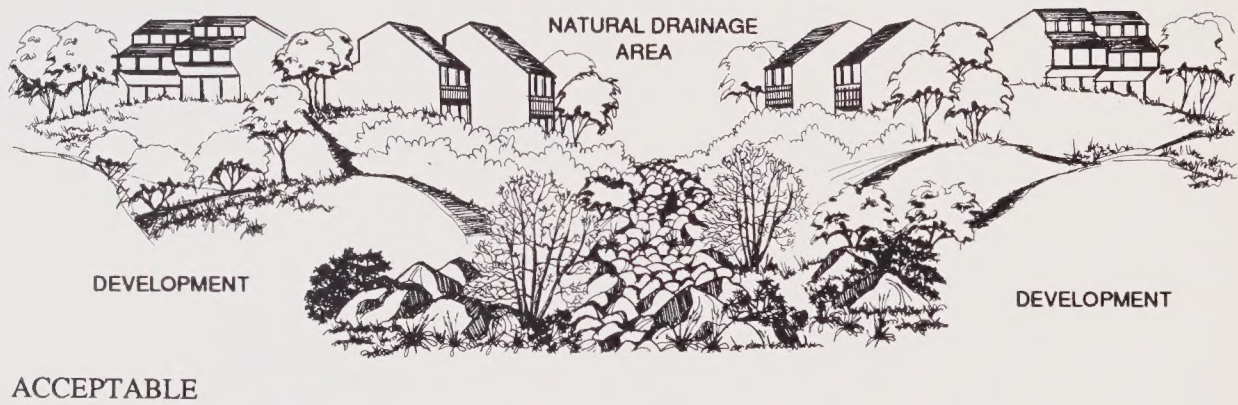
- Use decks instead of patios to reduce the amount of grading. Site decks on the roof of the garage or house, or extend from the house.
- Schedule grading during the dry season of the year and provide for dust control.
- Connect natural areas on site to provide continuity of plant material and a viable wildlife corridor.



Drainage & Erosion

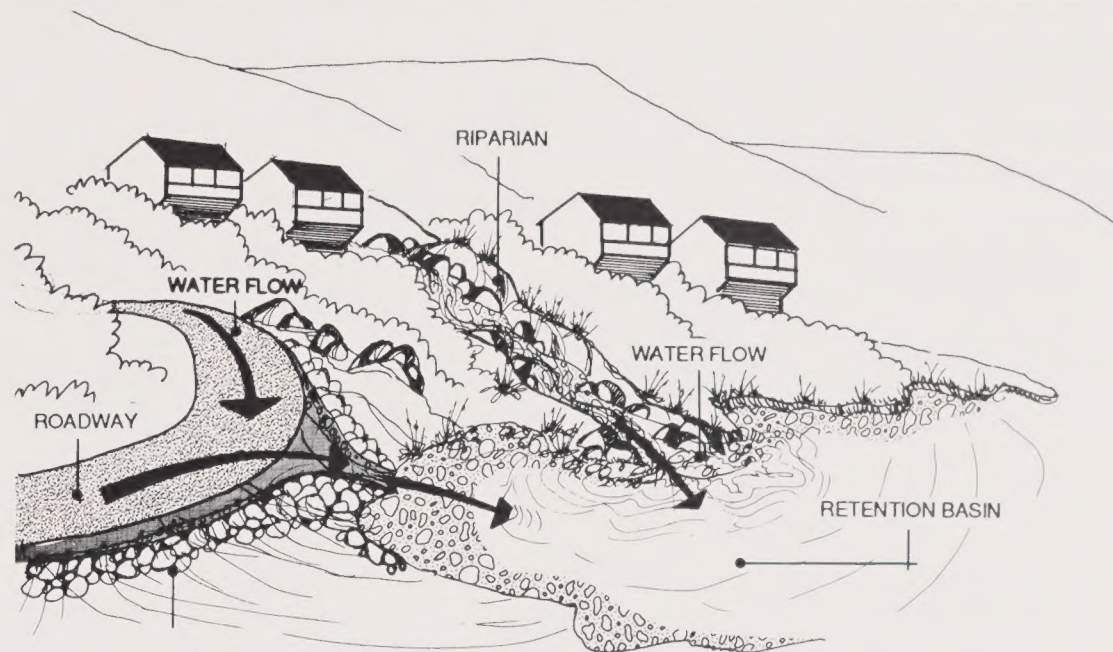
The natural water systems should be protected and utilized . Water falling on the land, naturally or artificially, should be retained and reused as much as possible. The protection of water courses will ensure the natural flow of water across the land for water infiltration to replenish the water table and for retention of riparian habitat areas. By retaining the natural drainage areas erosion will be minimized as will danger to houses and property.

- Leave drainage areas as natural as possible.
- Provide safety features such as catchment basins for unstable natural slopes.

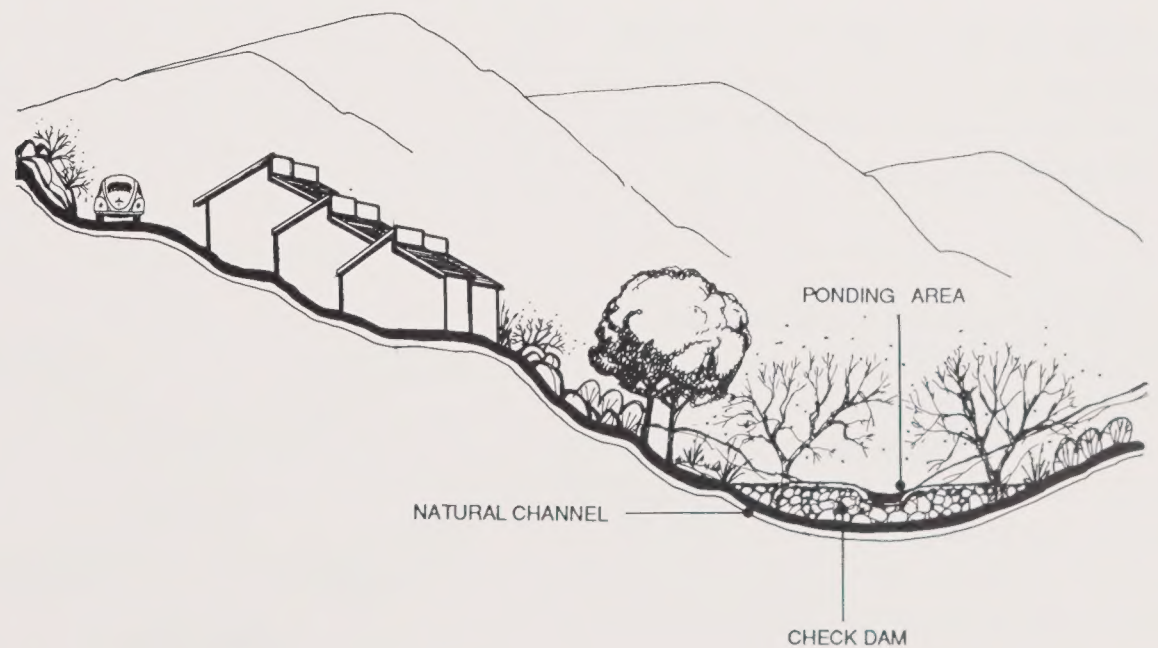


- Limit run-off to quantity flowing under natural conditions. Erosion in drainage ways shall not be increased due to development.

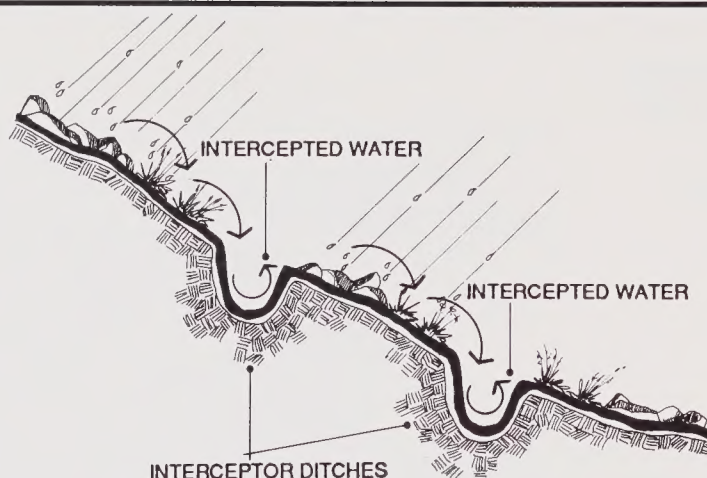
- Develop lots to maximize amount of rainfall which can be percolated into the soil and to minimize direct overland runoff onto adjoining properties, water courses, and streets.



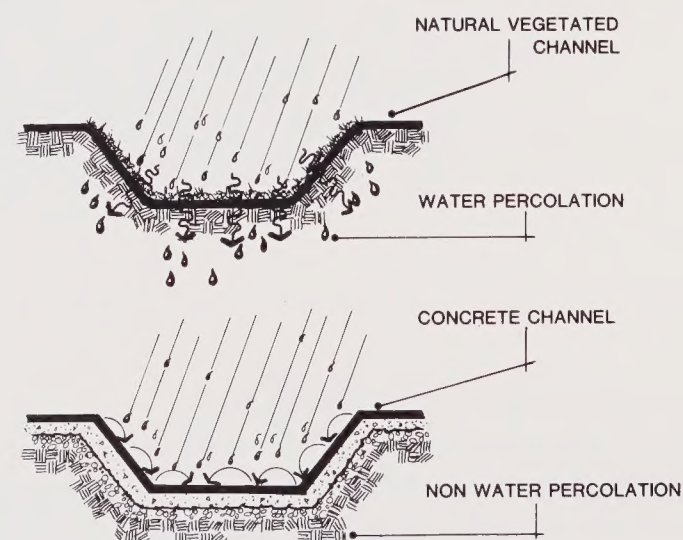
- Avoid using concrete channels on site. They prevent infiltration and destroy habitat. Instead, use natural drainage courses, retention basins and ponding areas to permit the detention of runoff which contributes to downstream erosion, flooding, and water pollution.



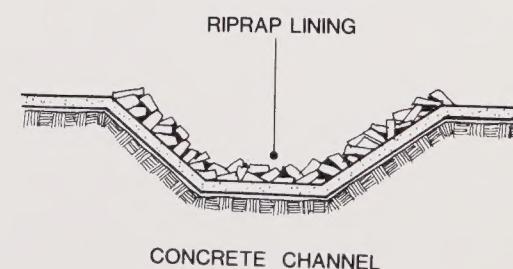
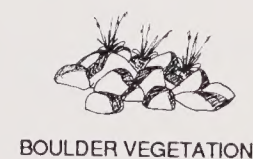
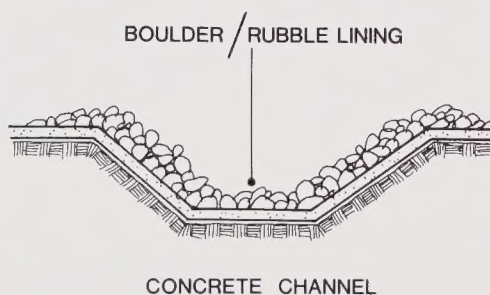
- Interceptor ditches should be established above slopes when appropriate and the intercepted water conveyed to a natural drainage way and to a stable channel.



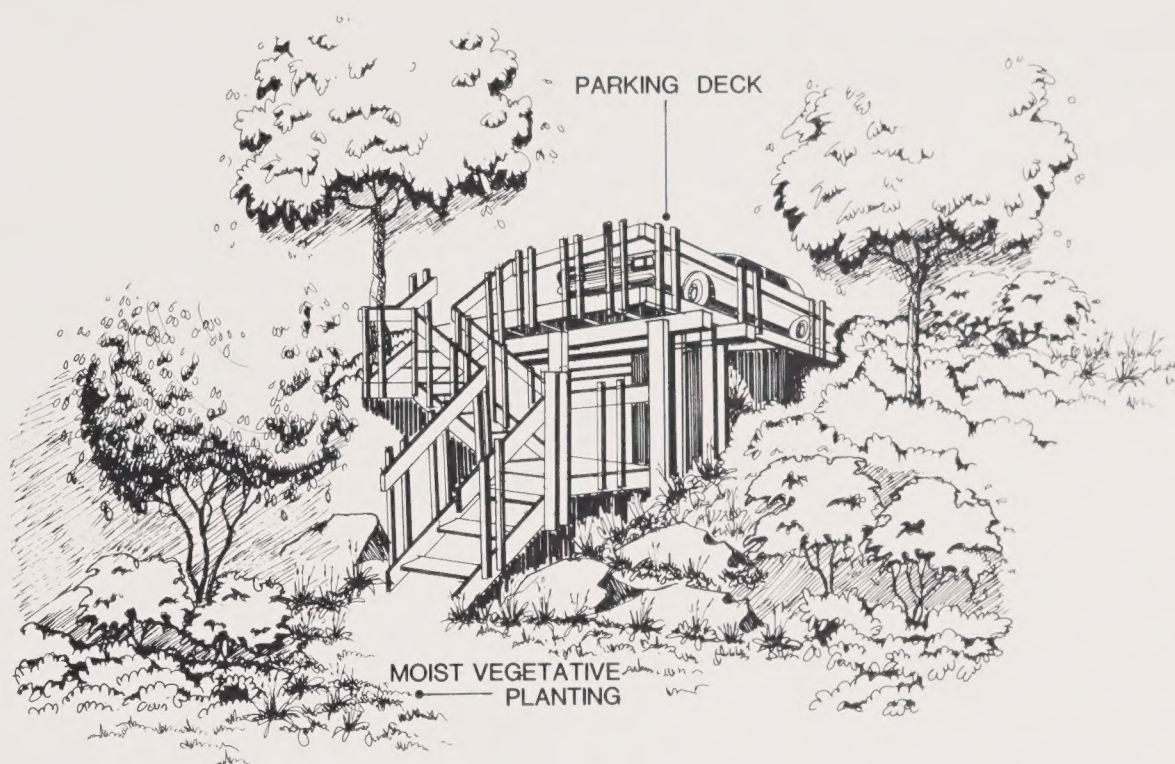
- Use natural colored materials if concrete drainage swales must be constructed. Use plantings to make swales blend with the background.



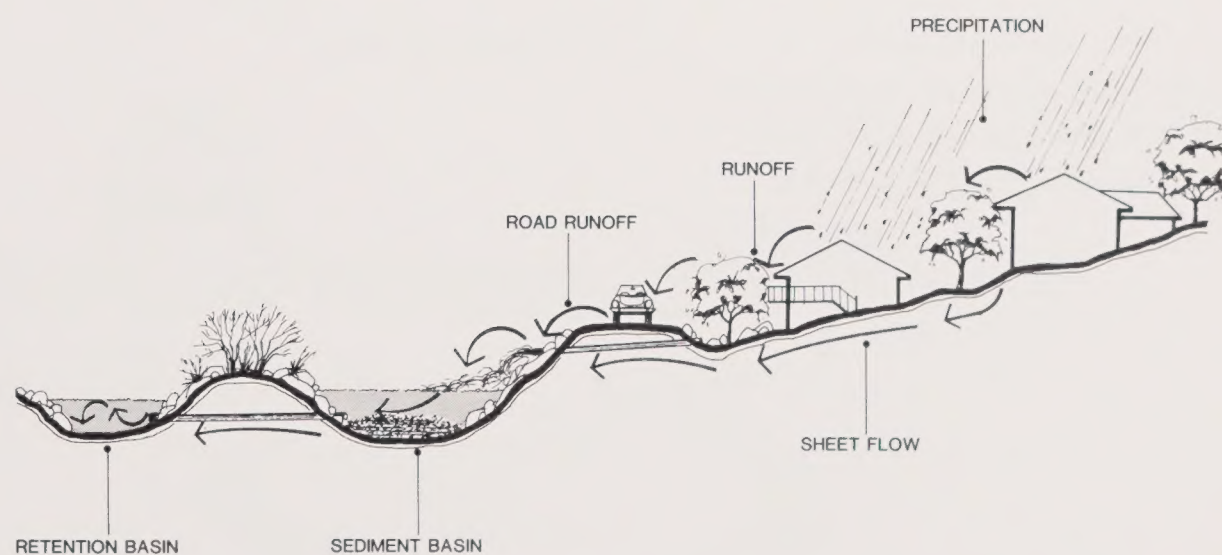
- Grade and landscape in increments of workable size which can be completed during a single construction season. Coordinate erosion and sediment control measures with grading and construction operations. Hydroseeding, berms, interceptor ditches, sediment traps, ponds, and recharge basins should be put into effect prior to or immediately after grading.



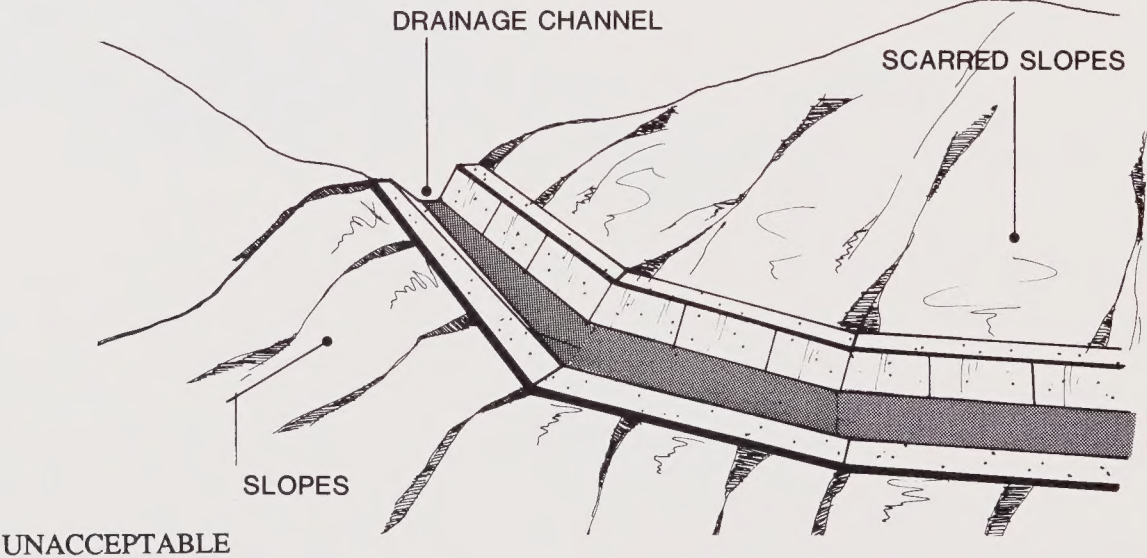
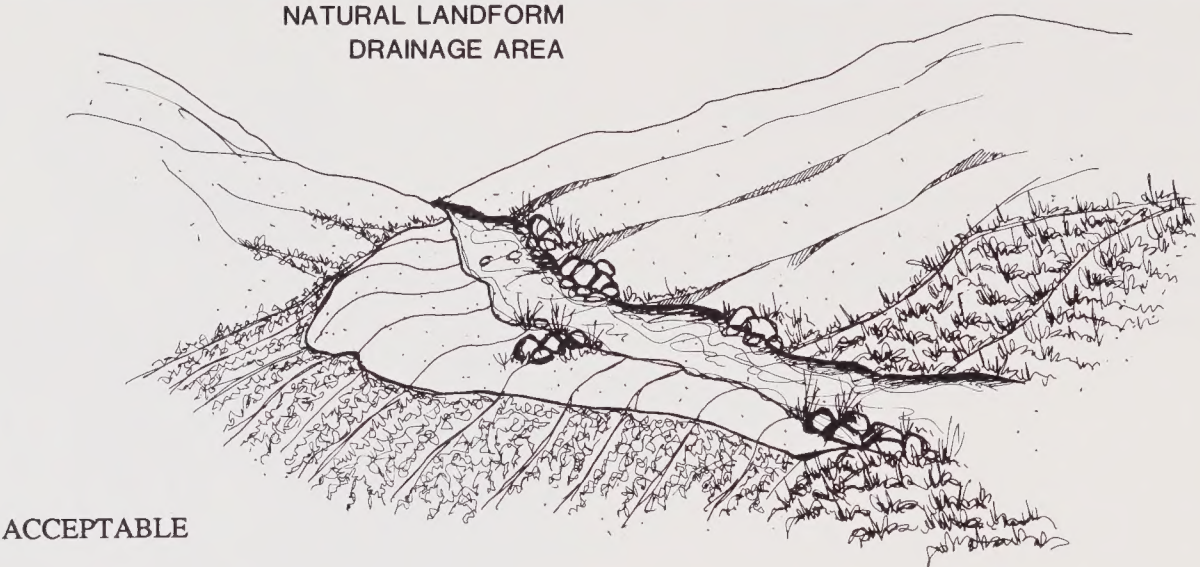
- Consider use of wooden decks or porous asphalt instead of concrete slabs for patios and parking. This will increase percolation and reduce run-off.
- Reduce width of streets, reduce sidewalk areas, and use common driveways and cluster units to minimize the impervious surface area of a development.



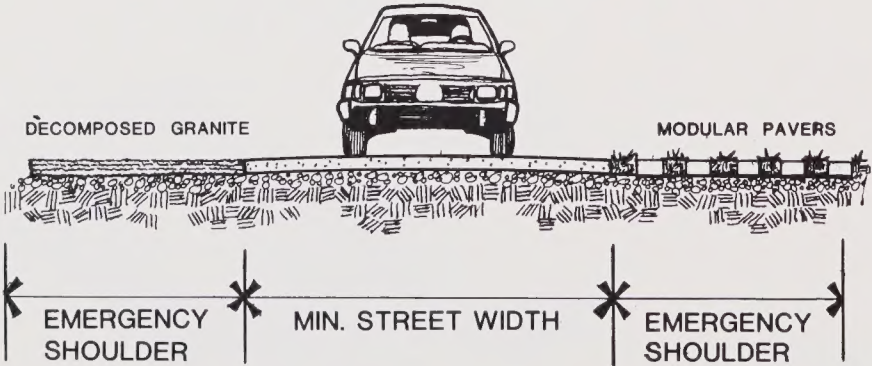
- Send water to recharge basin whenever possible.



- Angle swales along a slope rather than creating an abrupt 90 degree intersection



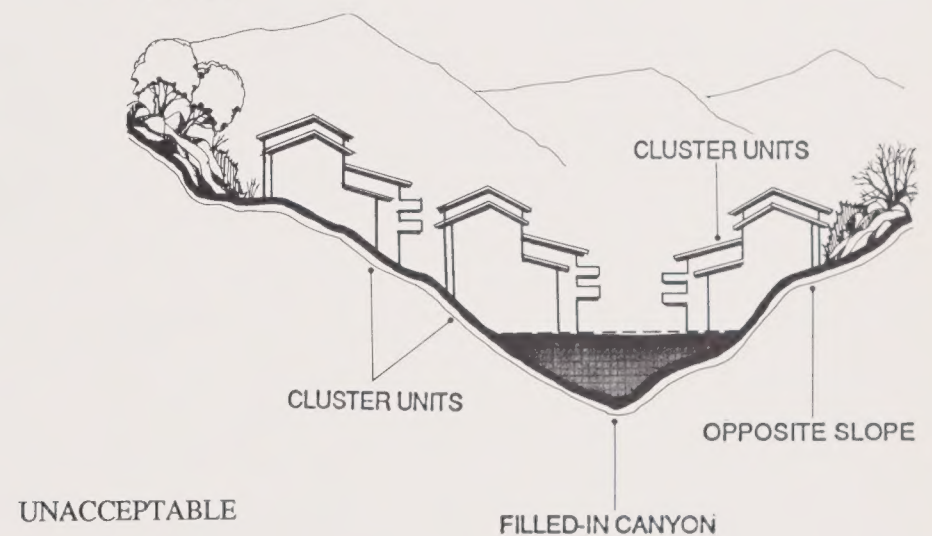
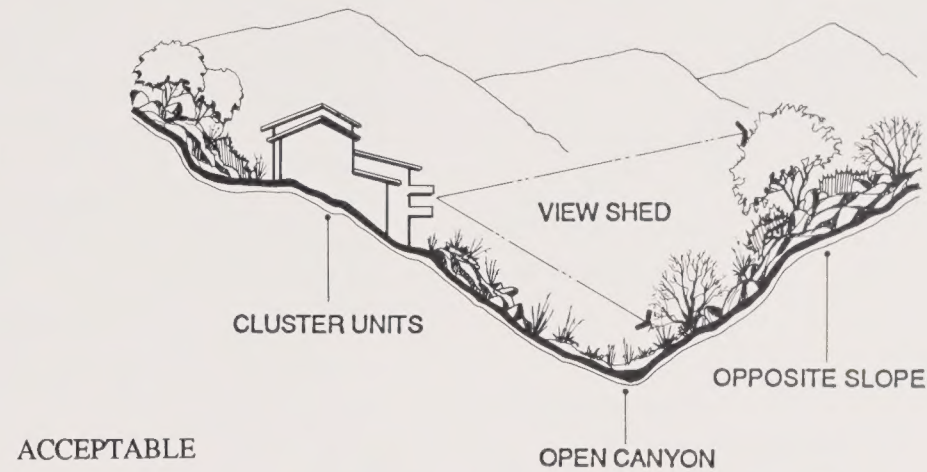
- Provide porous materials whenever possible. This could include dutch drains, porous asphalt, or modular paving.



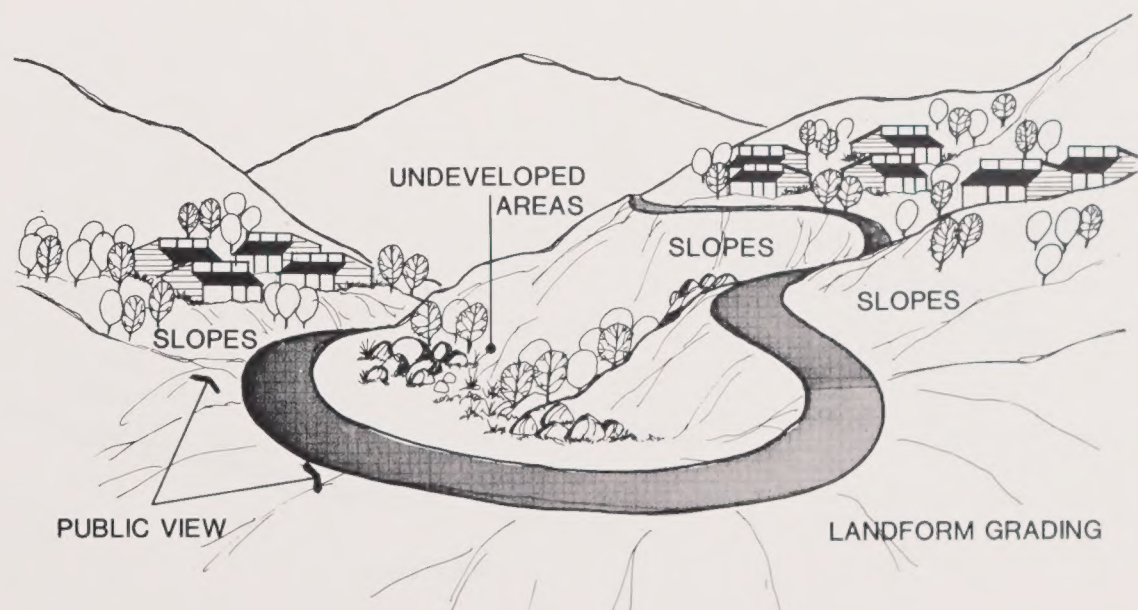
Siting of Structures

Design and locate structures so they fit with the contours of the hillside and relate to the overall form of the terrain.

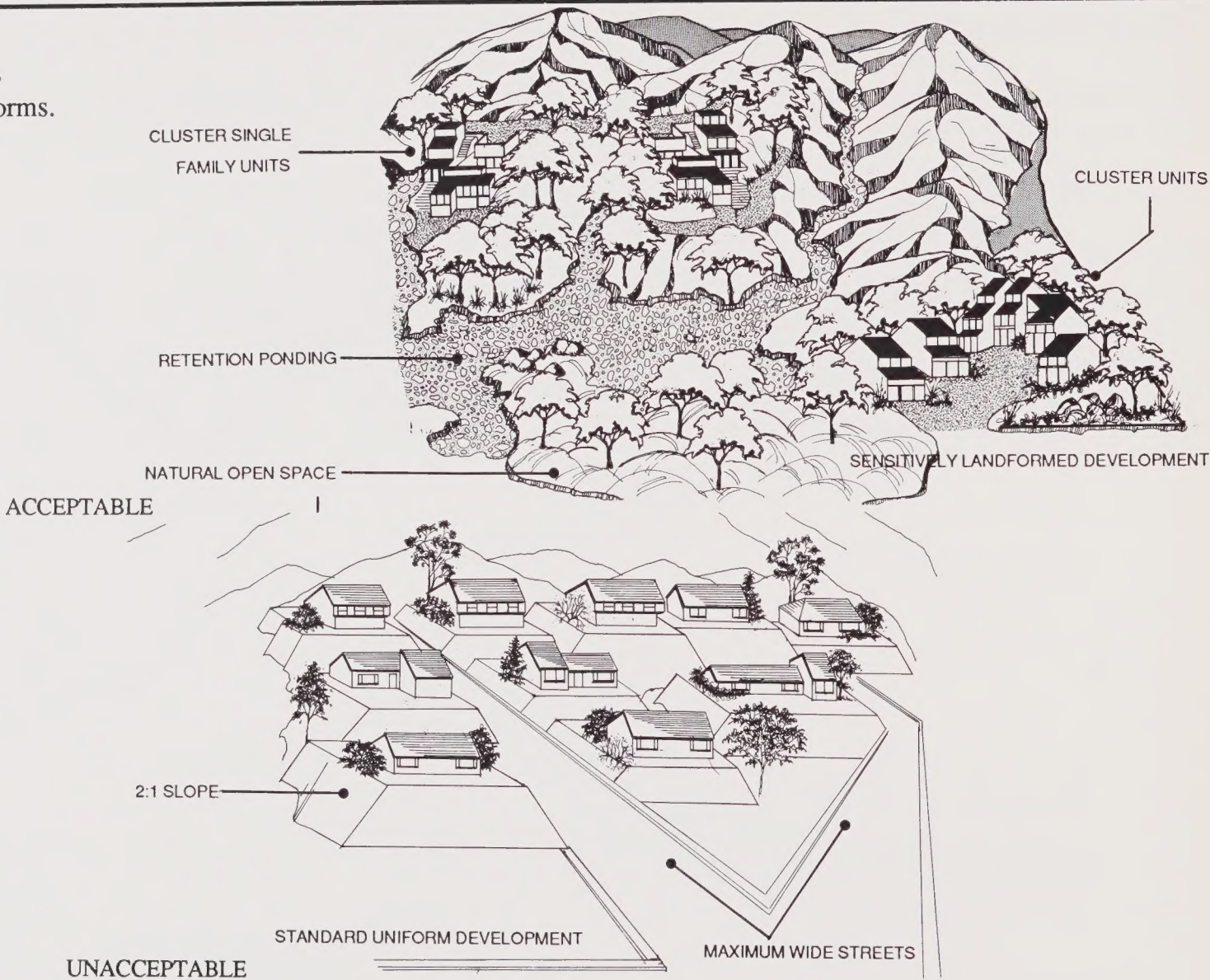
- Avoid development near open canyons to protect the watershed, to emphasize the existing topography, to conserve existing resources and to preserve large areas of undeveloped space and significant natural features.



- Allow for different lot shapes and sizes, with the prime determinant being the natural terrain.

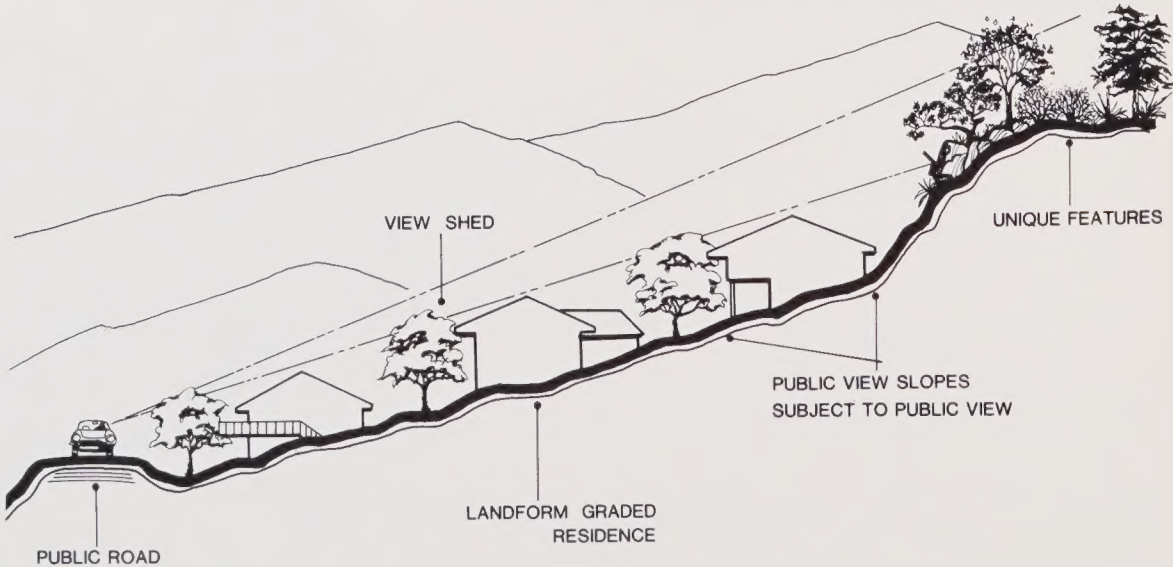


- Avoid uniform, terraced building sites which are contrary to the natural land forms. Instead, provide sites which fit into the terrain and allow for the least possible amount of graded land.



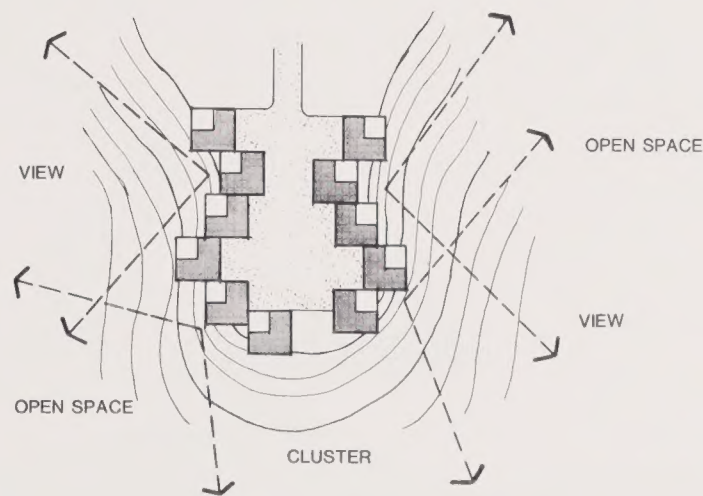
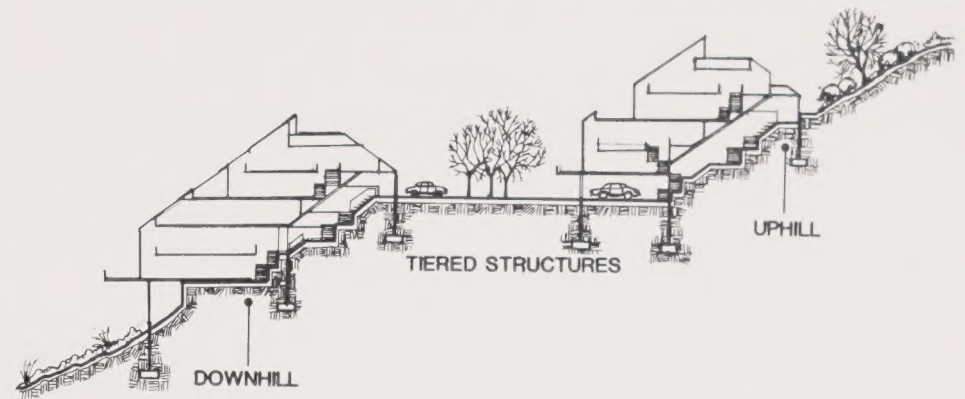
- Site individual and groups of structures to incorporate views to and from the hillsides and other natural features.

- Use flag lots if the result is the preservation of topography by minimizing grading and the protection of view slots.



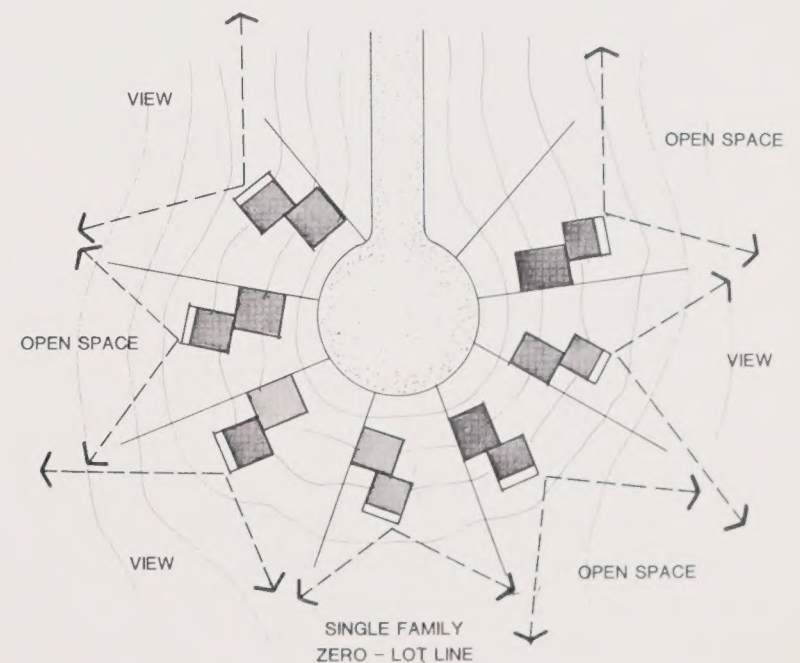
- Encourage stepped foundations to minimize grading on steep and sensitive hillsides.
- Minimize coverage by using multi-level structures.

- Place structures as close to the street as possible on steep slopes to preserve the natural terrain and minimize the need for long driveways.



- Consider zero-lot line developments if visual or open space qualities can be gained.

- Place all utilities underground. High voltage overhead transmission lines and towers that cannot be put underground should be routed to minimize detrimental scenic impacts.



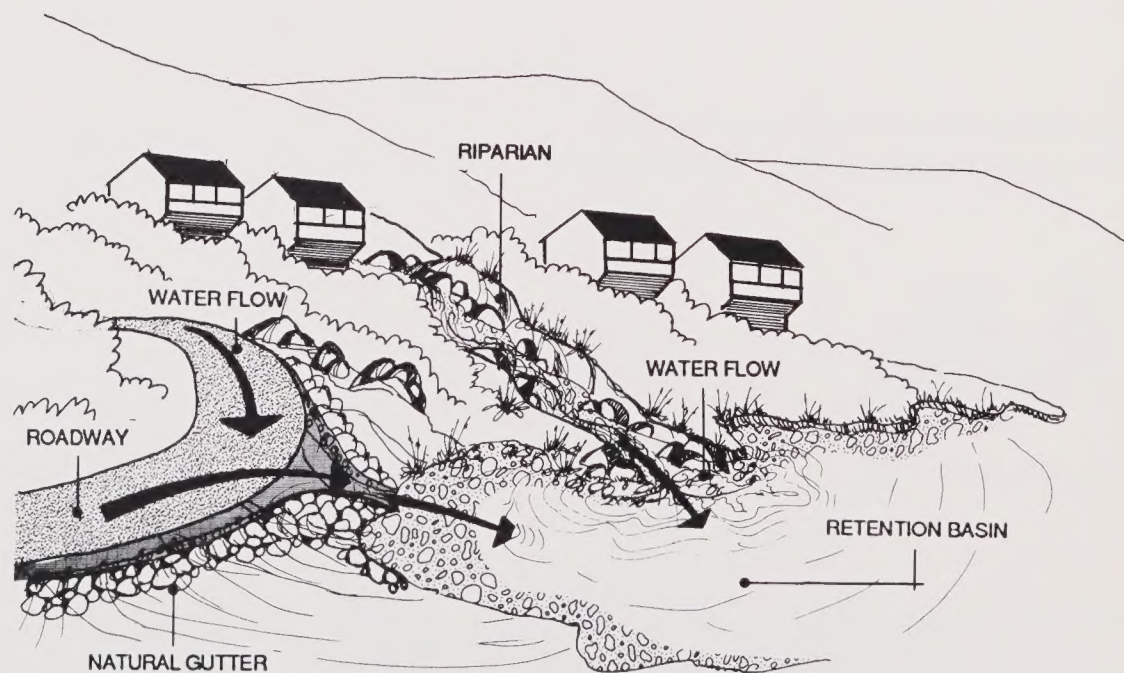
Streets

Street standards should reflect the topographic character of hillsides.

- Design roads to generally follow the natural contours, emphasize existing hillside topography, significant trees and major rock outcroppings. Minimize cut and fill.

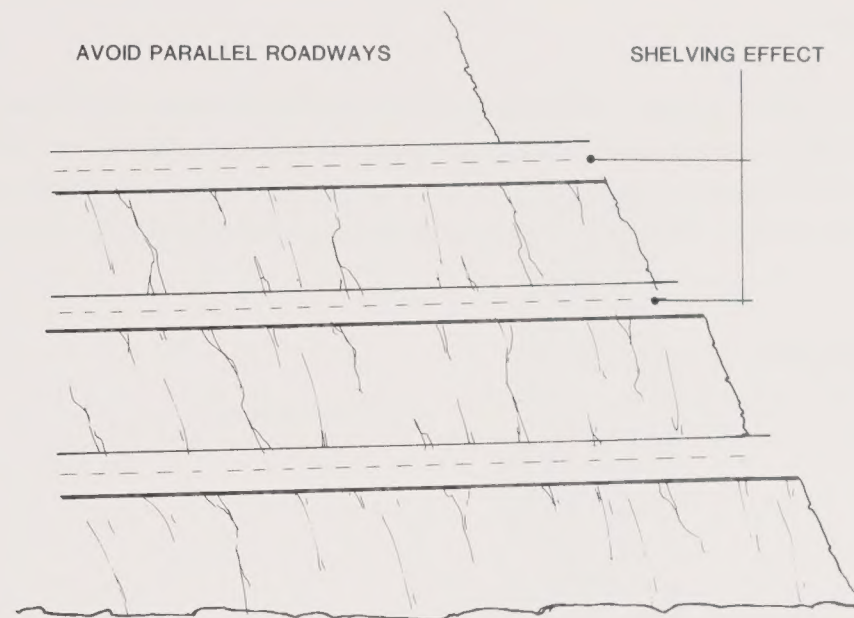


- Prevent water from flowing off the roadway in an uncontrolled fashion. Flows should be directed to swales and retention basins.

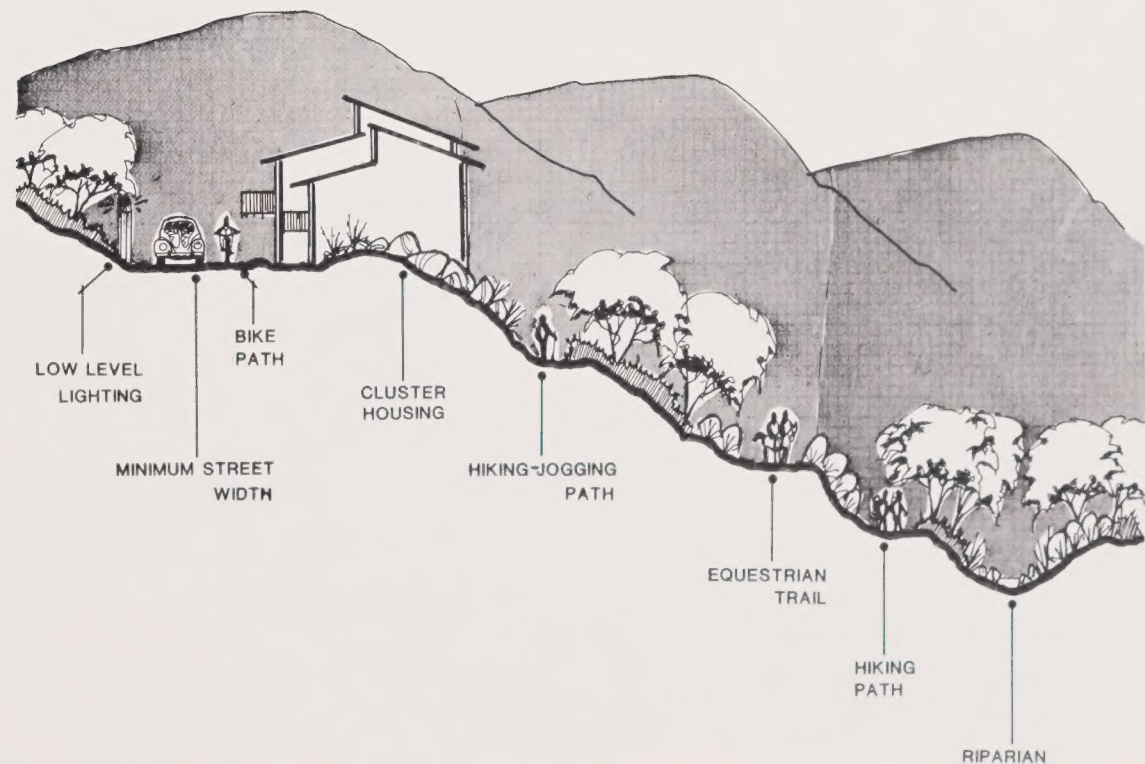


- Keep road widths to a minimum on hillsides. Use porous material wherever possible. This could include porous asphalt, or modular paving. Modular paving can also be a means of increasing width of roads for fire safety

- Avoid parallel roadways which create a shelving effect.



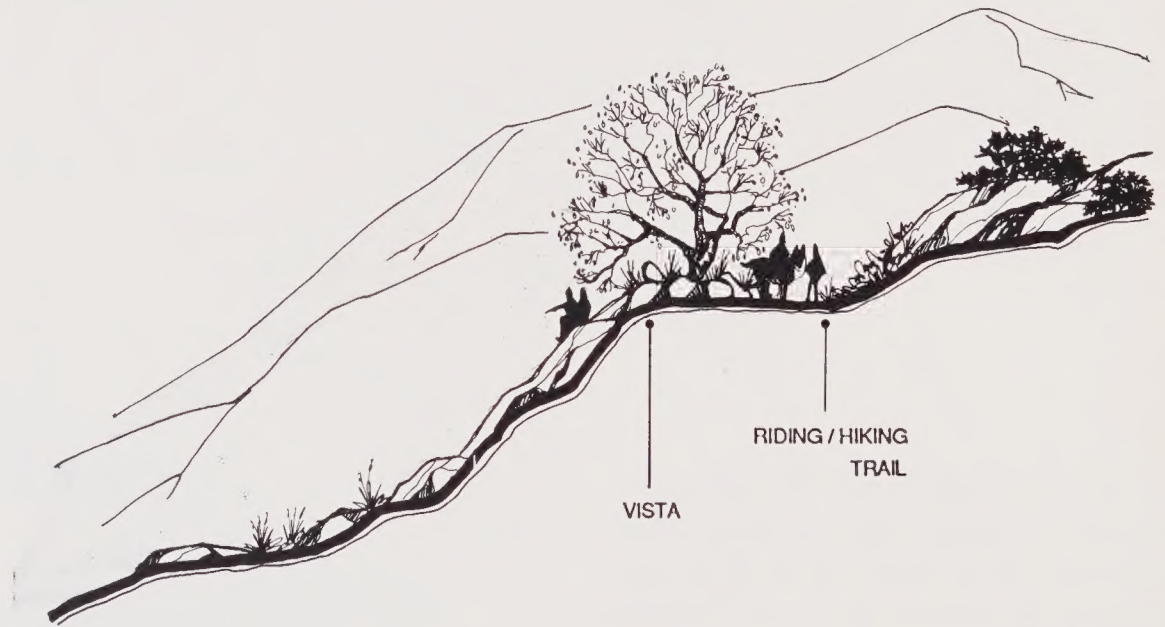
- Design street improvements, including fencing, sidewalks, signs, pathways, and lighting to help create a sense of identity and individual character for each neighborhood development.
- Keep street lighting in hillside areas to a minimum, unobstructive and of low profile design
- Minimize length of roads but keep within the City's 700' cul-du-sac limit.
- Encourage cul-de-sacs, loop streets and common driveways. Cul-de-sacs must provide sufficient turning radius to accommodate fire trucks.
- Streets in hillside areas should not be steeper than 15%.



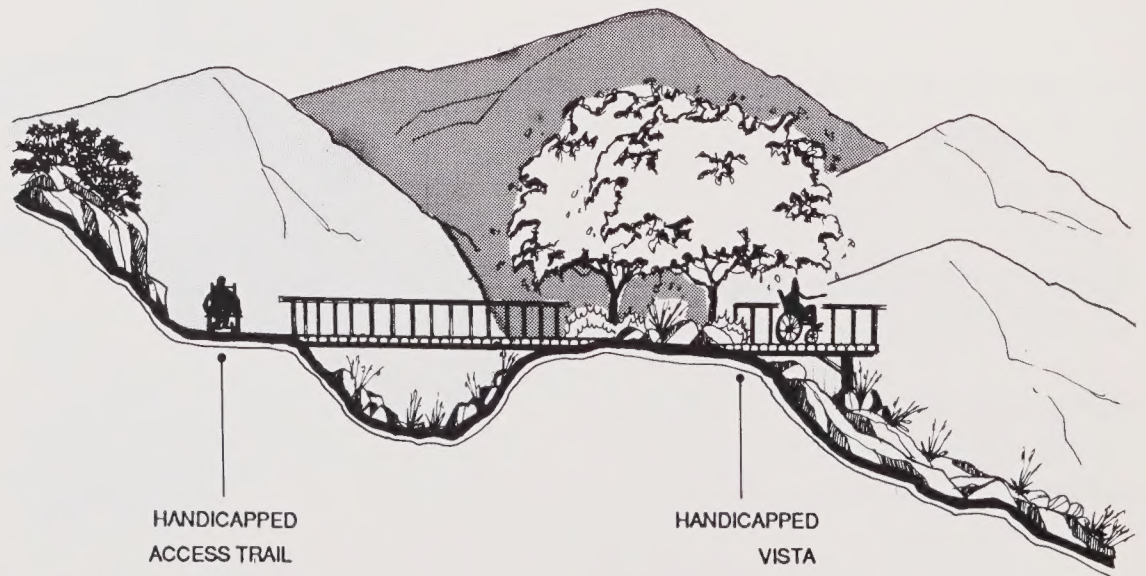
Trails and Sidewalks

Hillside development offers a unique challenge to develop safe sidewalks and trails. Sidewalks are important because they provide safe passage for pedestrians. Equestrian and hiking trails should be developed throughout the areas to provide connections between natural areas on site and any nearby trails or parks. These trails also serve as alternative means of circulation.

- Maximize public access to canyons, overlooks, vistas or undeveloped land through pathways and trails.



- Handicapped access should be provided to canyons, overlooks, vistas or undeveloped land whenever possible.

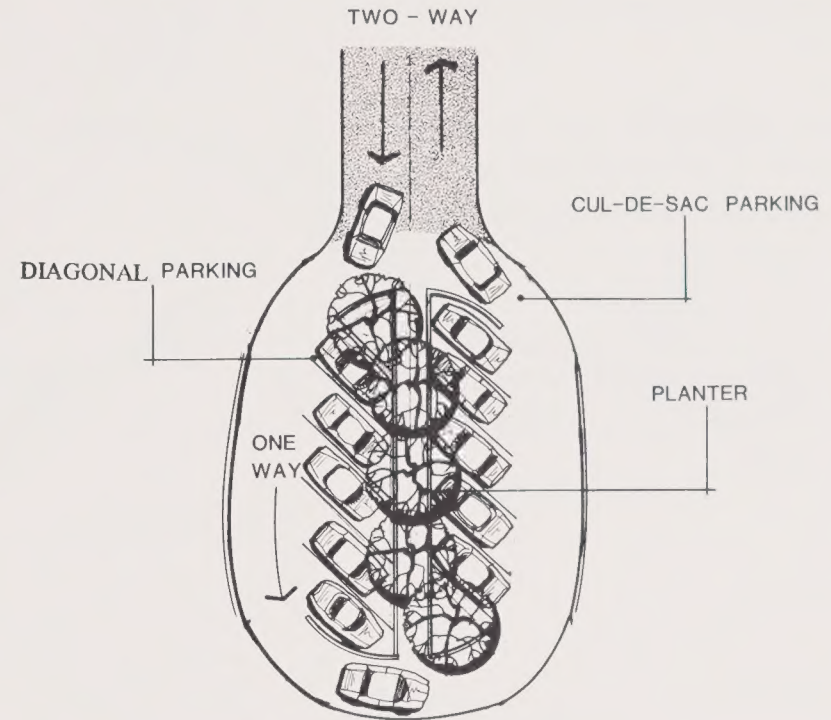


- Integrate bicycle, walking and equestrian trails into the overall circulation plan for any project.
- Design sidewalks on only one side of the street to reduce impermeable surface area.

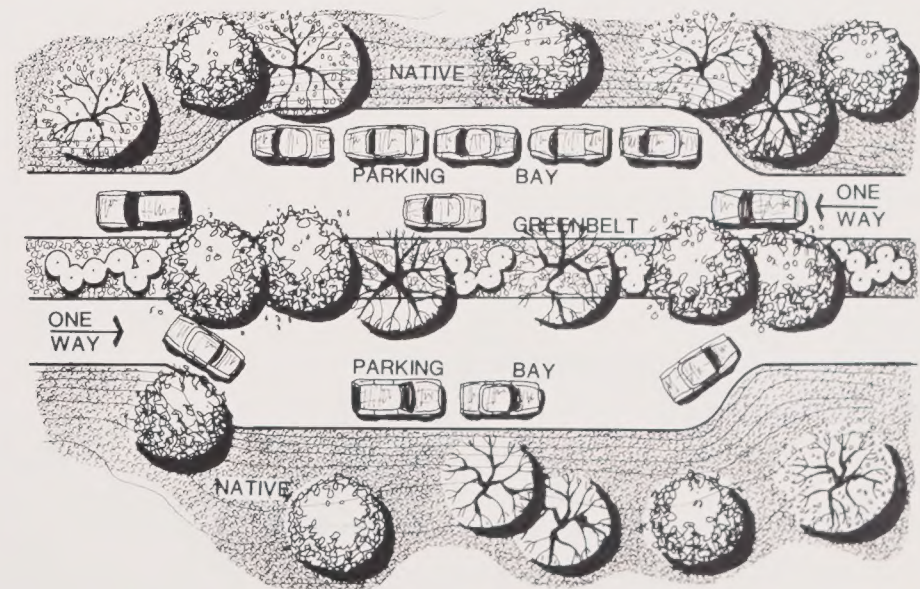
Parking

Natural character is lost when streets are wide enough to accommodate on-street parking.

- Provide parking which is unobtrusive, and does not cause additional grading on the road.
- Locate non-emergency parking offstreet or in parking bays.



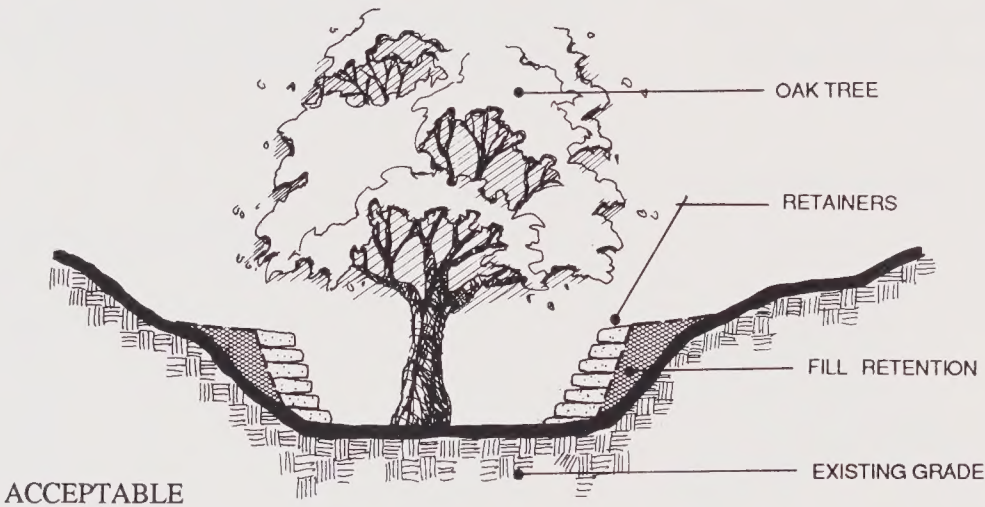
- Consider reduction in street width when adequate off-street parking is provided. Intermittent widening of streets for clustered parking areas and bays should be encouraged at appropriate locations.



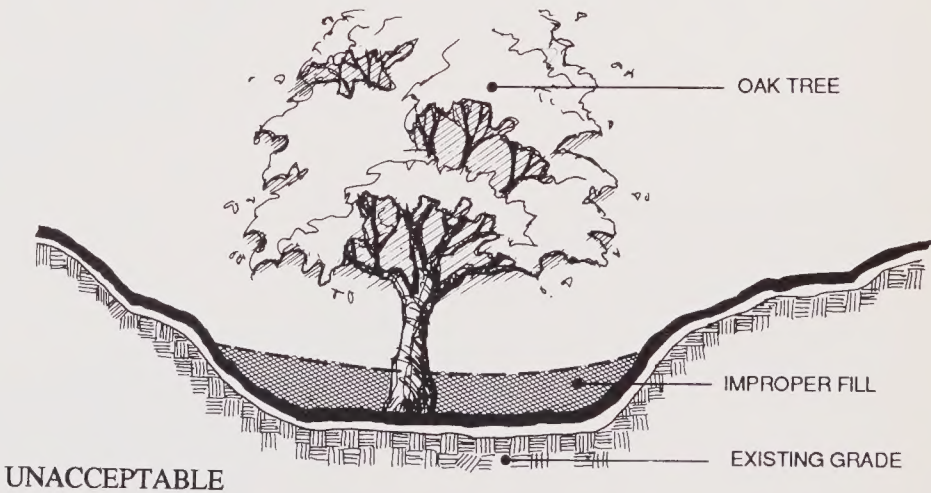
Vegetation

New vegetation should reflect specific uses in terms of water needs, fire protection, visual buffers, and recreational activity.

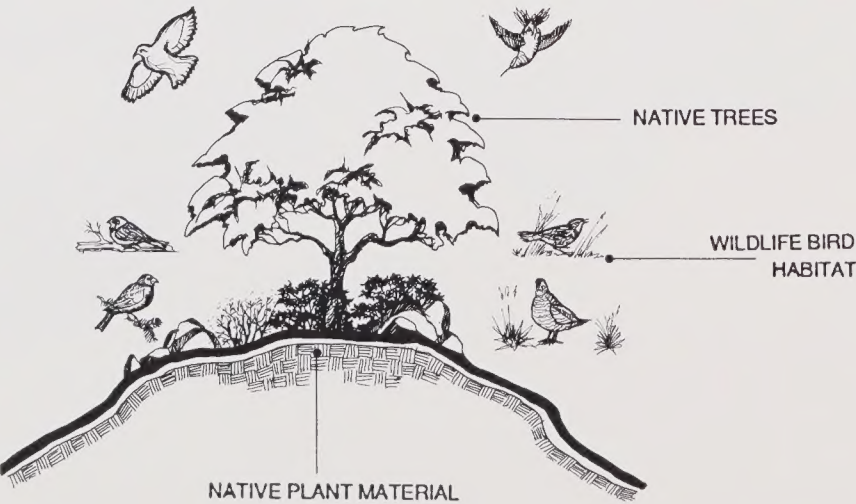
- Retain all oak trees at grade, especially those growing in cluster situations. Conform to the Oak Tree Ordinance for the City of Los Angeles.
- Maintain the ground area within the dripline of native trees using plant materials typical of that habitat.



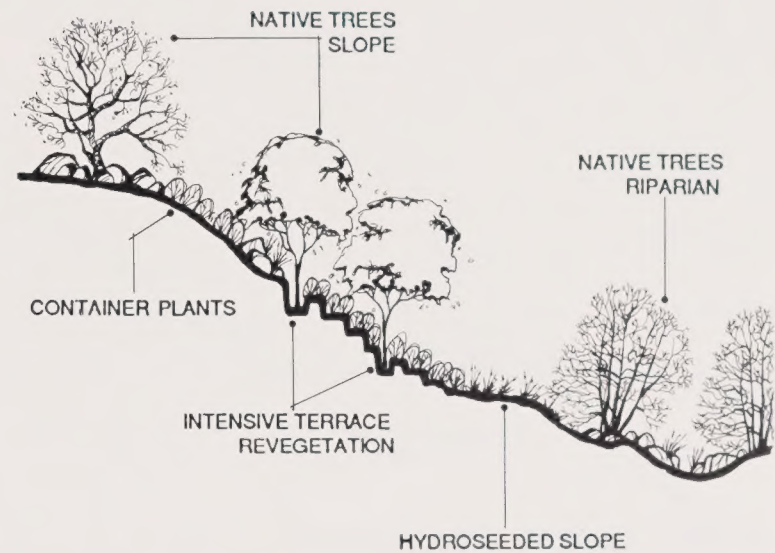
- Attempt to provide plant materials native to the area as they have the greatest opportunity not only for successful growth, but for support of indigenous birds and other wildlife.
- Reduce lawn areas whenever possible.



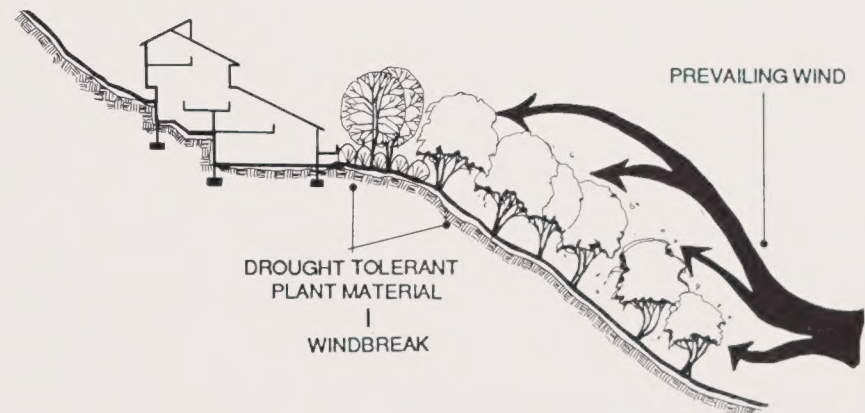
- Design irrigation systems to last as long as required for the selected species to become established.
- Provide all manufactured slopes with a ground cover that will insure 100 percent coverage within one year.



- Revegetate all graded or disturbed areas which are not otherwise developed or protected from erosion.



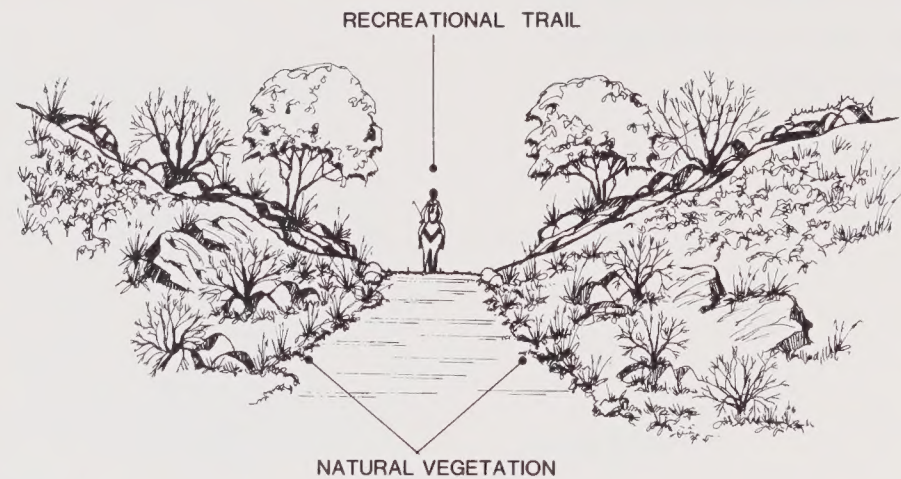
- Consider drought tolerant materials for windbreaks, hedges and erosion control.



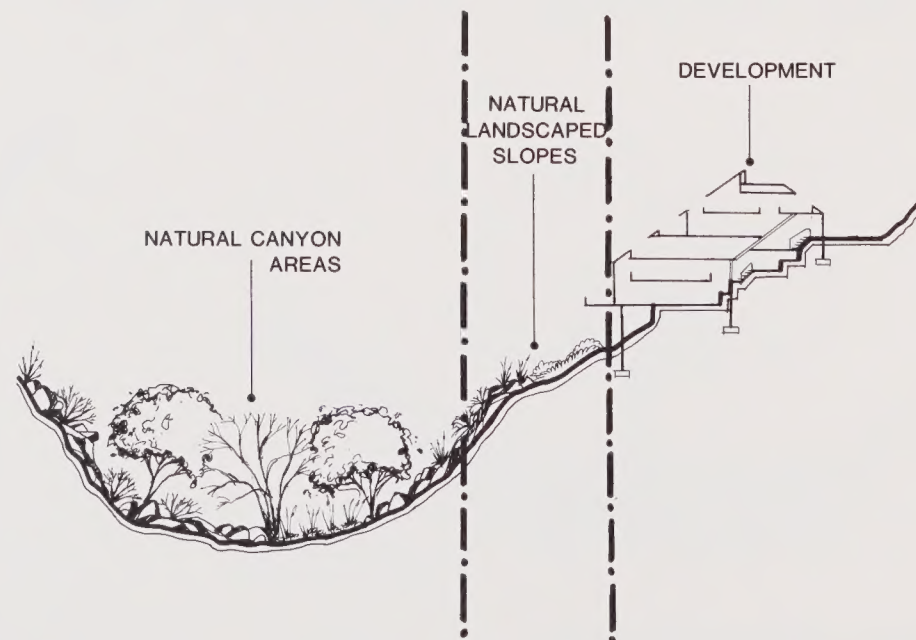
- Design revegetation in terms of patterns, plant densities, over and understory, open areas, edges and plant selections to create communities appropriate for chosen land uses.
- Work toward self-sustaining plant communities.
- Eradicate introduced weed species to ensure the healthy revegetation of native plant materials.



- Retain natural vegetation along recreational trails.

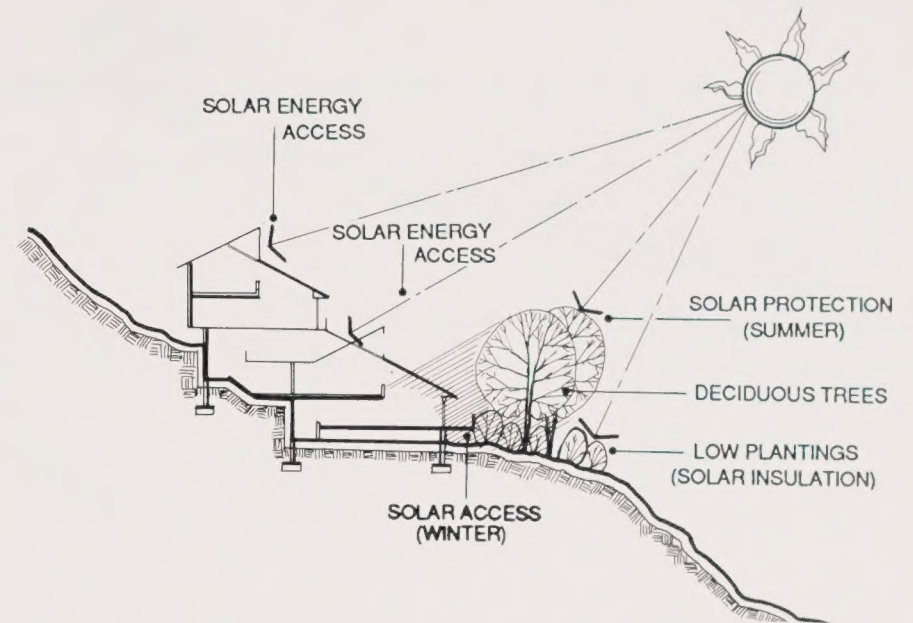


- Preserve the native plants on slopes adjacent to natural canyon areas.

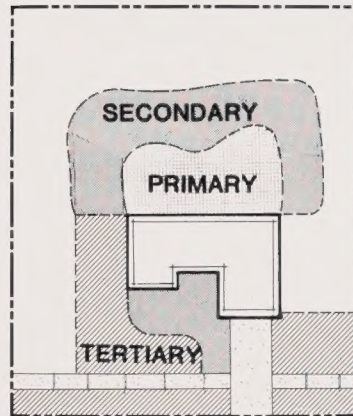


- Identify and correct soil problems before revegetating area
- Enhance the blending between manufactured and natural slopes with drought tolerant native plant material.
- Plant all manufactured slopes with erosion control, fire resistant, and self-sufficient plantings. See list in appendix.

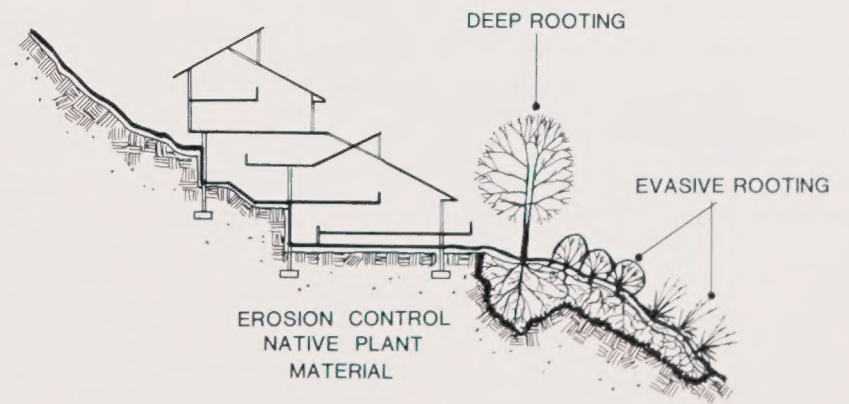
- Plant trees to control solar radiation. Deciduous trees allow for some winter solar heating but still block up to 40% of solar radiation.
- Use shrubs around structures to reduce solar reflection during the summertime.



- Group plants of similar water usage for zonal irrigation.



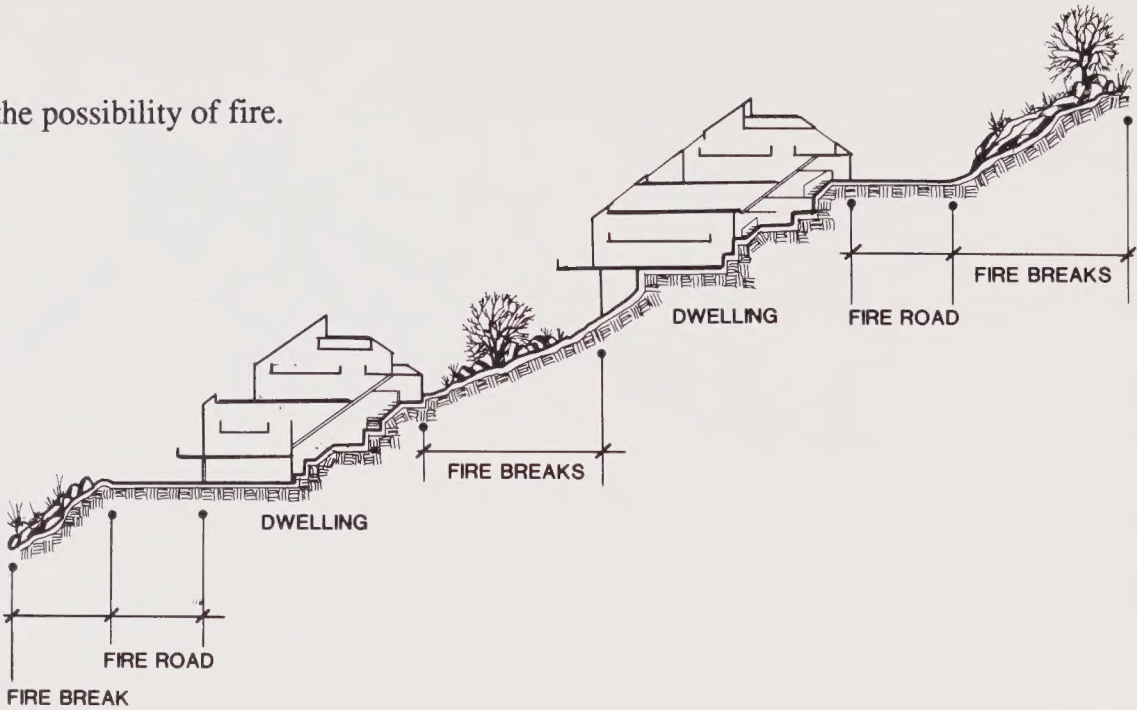
- Use low-growing shrubs to stabilize soil and prevent erosion.
- Attempt to provide plant materials native to the area as they have the greatest opportunity not only for successful growth, but for support of indigenous birds and other wildlife.
- Refer to the City's Xeriscape ordinance in early planning stages



Fire Prevention

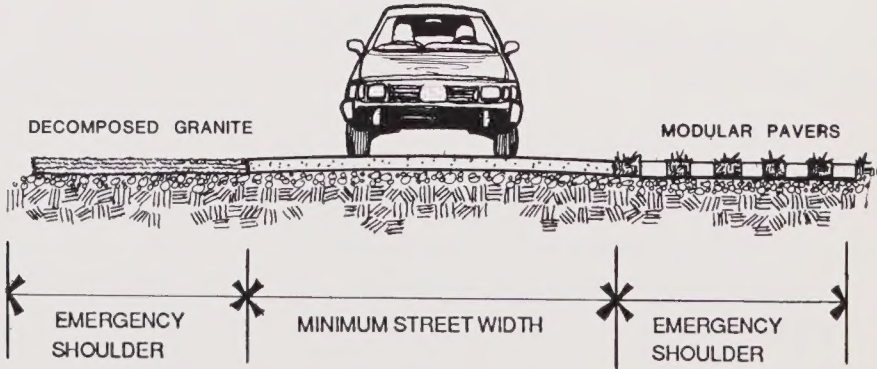
Development should include safety provisions to minimize the possibility of fire.

- Plan fire breaks or fire roads to protect both developed areas and the watershed.

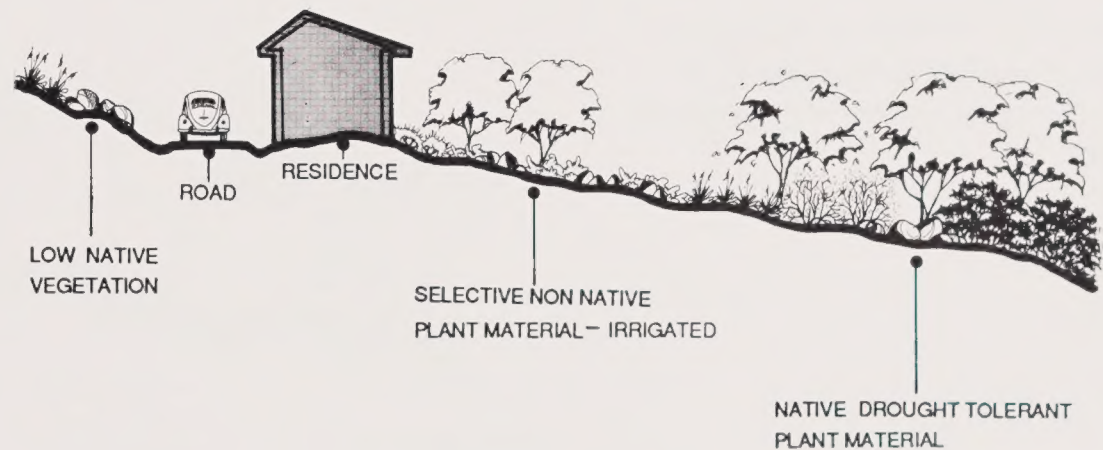
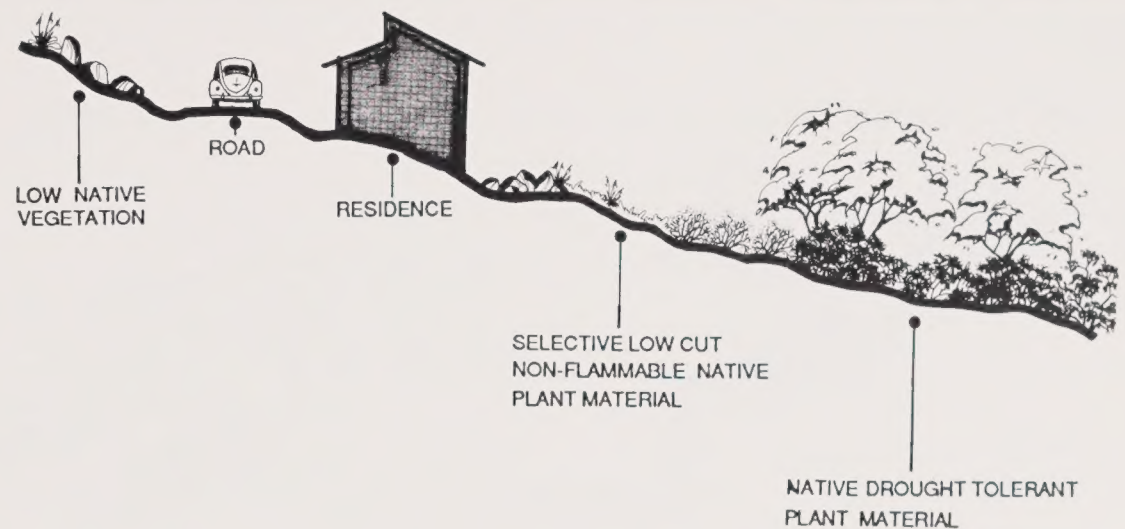


- Provide two or more points of access to be used in an emergency.

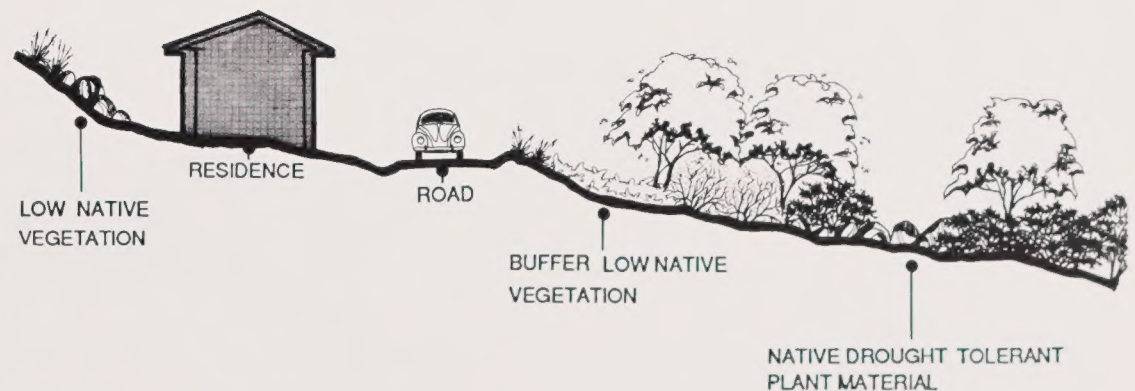
- Provide safe and ready access for fire and other emergency equipment. This does not mean unnecessarily wide streets. Proper road use of non-permeable right of way would allow maximum safety with minimum road width.



- Provide a fire resistant zone by planting with non-flammable vegetation around buildings or by using fuel modification techniques. Trees, ornamental shrubbery, or similar plants of low combustibility are best advised. See listing of plant materials in the appendix.
- Use fire retardant roofing, building materials and decks in all hillside areas.



- Provide access for fire equipment to be used in regular controlled burns surrounding a subdivision.
- Provide hydrants in such places as to protect structures during the times of controlled burns.



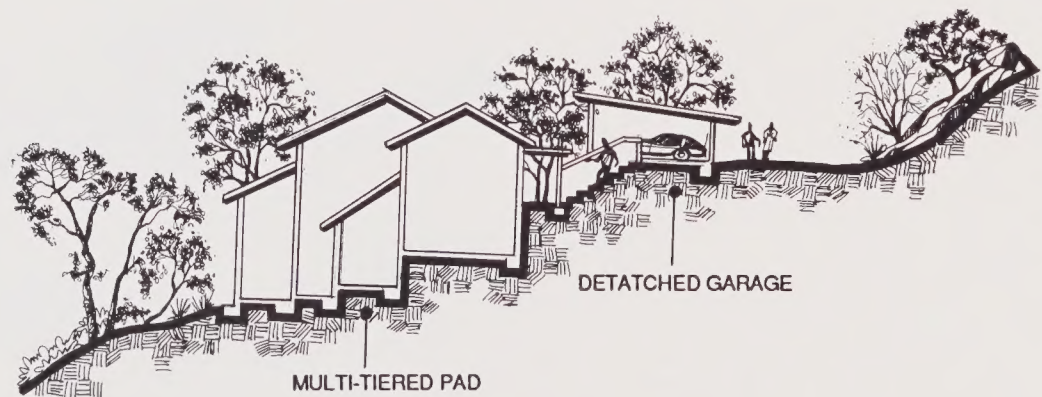
Architecture

Use variation in architectural design to allow structures to blend into the natural terrain.

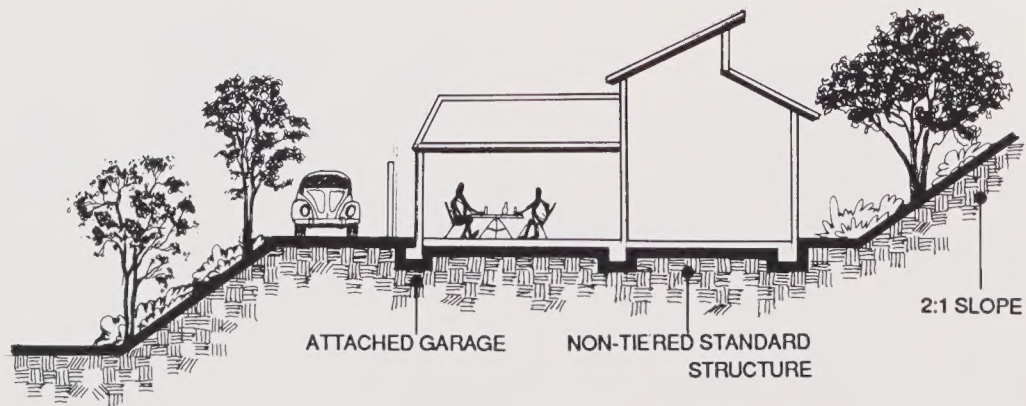
- Design structures to fit into the hillside rather than altering the hillside to fit the structure.



- Minimize slope coverage by using tiered structures. Consider the possibility of detached garages to give more topographic flexibility.

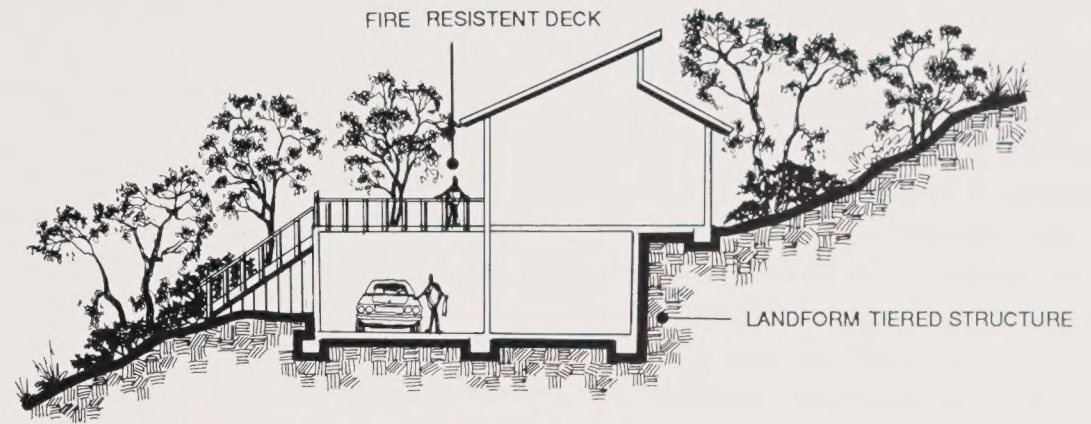


ACCEPTABLE

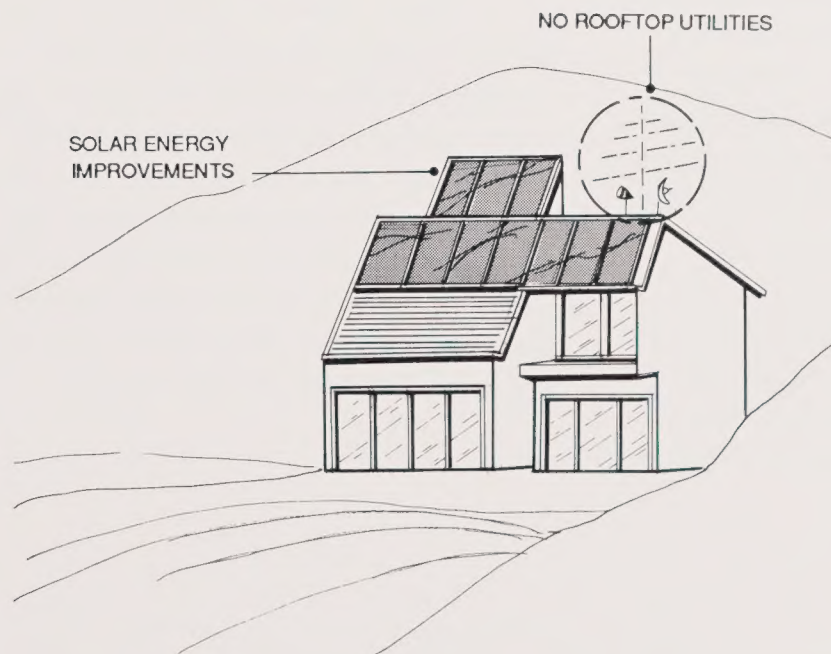


UNACCEPTABLE

- Use only fire-retardant wooden decking materials and clear area beneath deck for fire safety.



- Avoid rooftop utilities except for solar-energy improvements. These improvements should be an integral part of roof design.



- Vary the treatment of buildings and rooftops to blend with the mosaic pattern of the surrounding soil and vegetative cover.

ALTERNATIVES

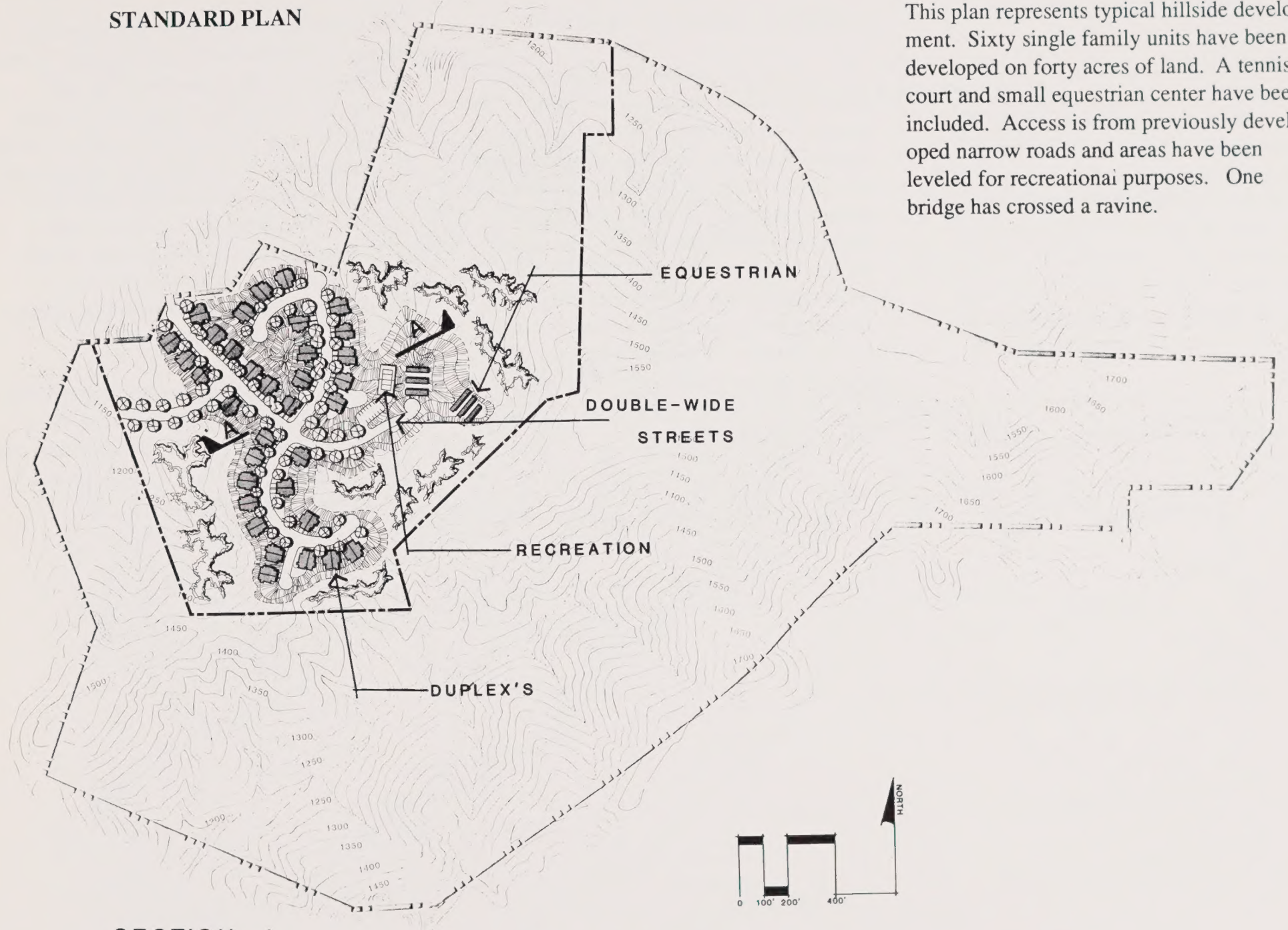
Using the suitability models to determine distribution of uses on the land and design guidelines to determine specific forms, the developer is in a position to begin considering design alternative. Designing for hillsides is different than flatland design: site design and architectural forms for flatter valley land do not work well with hillsides. By exploring alternatives it is possible to define the full range of development patterns and to search out those which are not only economically feasible but possibly more profitable than the usual form of subdivision. From the preparation of suitability models and design criteria, patterns will emerge that suggest various types of development. Having gone through the prior steps of the process the developer can be sure that he has done everything possible to provide alternatives that meet the goals of the city in terms of environmental sensitivity. Sketches, sections, and siting studies help to illustrate the design alternatives and provide means for reviewers to visualize the concepts portrayed. An architectural form which can relate to its neighbors in many different combinations, as needed, is most adaptive. A modular unit arranged according to existing contours, geological elements, and native trees works well.

SENSITIVITY COMPARISON

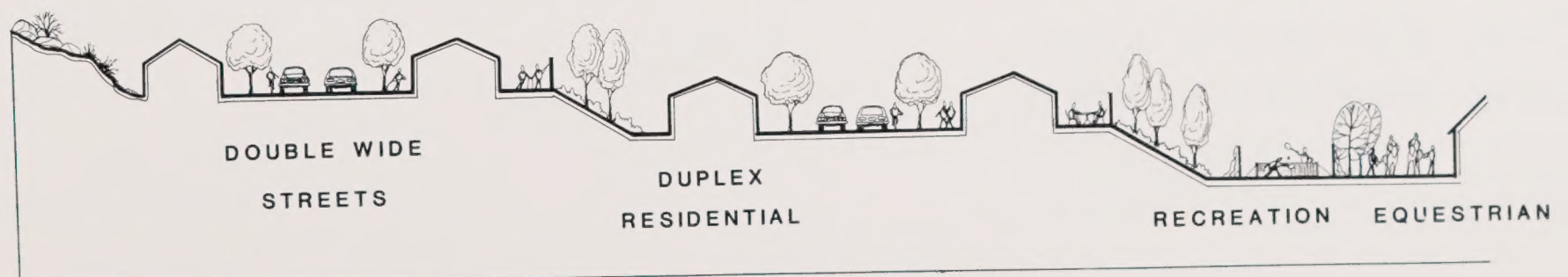
While it is impossible to put a dollar value on environmental considerations, it is not difficult to show the importance of maintaining ecological health and functioning of the land. This sensitivity analysis is devised to compare the alternatives in terms of their effect on the land. When these considerations are examined along with the analysis of long and short term costs, a particular alternative will usually emerge as most acceptable. This comparison examines the conditions determined by the Site Checklist.

In the following case study a typical hillside subdivision plan will be shown. Attempts have been made to adapt to city ordinances and something of a 'country atmosphere' has been retained. Then three alternative designs created by using the foregoing site design process will be introduced. The densities have been maximized to show that sensitive development can be accomplished with the higher density.

LAND USES					SENSITIVITIES							
AREA	ACRES	RESIDENTIAL	RECREATION	LOTS PER ACRE	HYDROLOGY	SLOPE	SOIL	GEOLOGY	BIOLOGY	ARCHAEOLOGY	VIEWS	MICROCLIMATE
1												
2												
3												
4												
5												
6												
7												
8												
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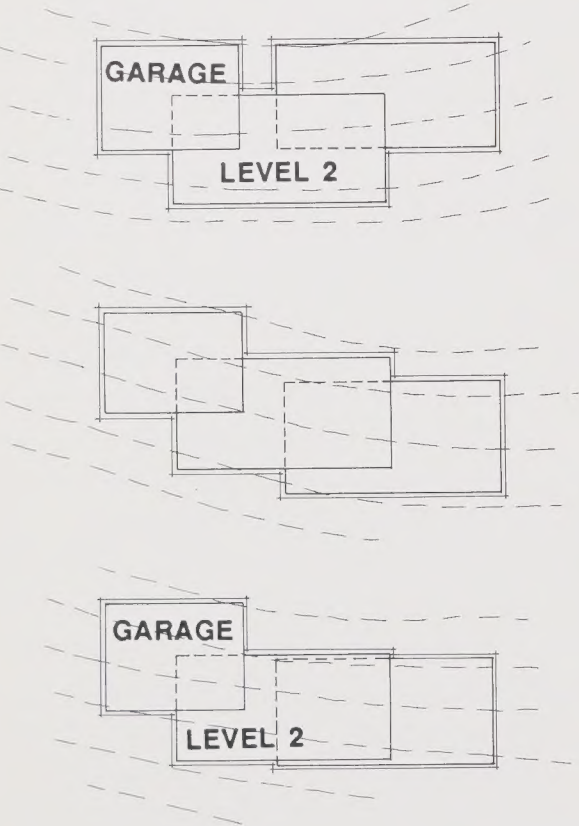
STANDARD PLAN

This plan represents typical hillside development. Sixty single family units have been developed on forty acres of land. A tennis court and small equestrian center have been included. Access is from previously developed narrow roads and areas have been leveled for recreational purposes. One bridge has crossed a ravine.

SECTION A

ALTERNATIVE 1

Alternative 1 provides a plan that focuses on the market demand for single family detached homes. The purpose of this alternative is to maintain as much natural open space as possible by concentrating development into a limited area. This allows more space to be devoted to the theme of 'country living' with an emphasis placed upon the equestrian atmosphere and the

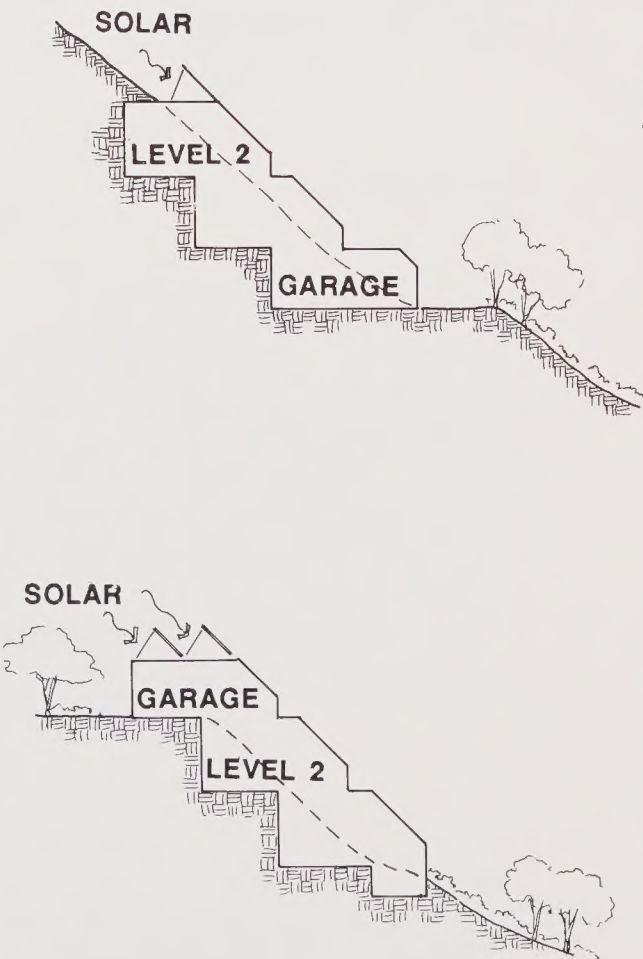


FLOOR LAYOUTS AND SLOPE RELATIONSHIPS

BUILDING FLOOR LEVELS TO MOVE IN CONJUNCTION WITH THE TOPOGRAPHY OF THE HILLSIDE IN ORDER TO CREATE A BLENDING OF STRUCTURE AND LAND.

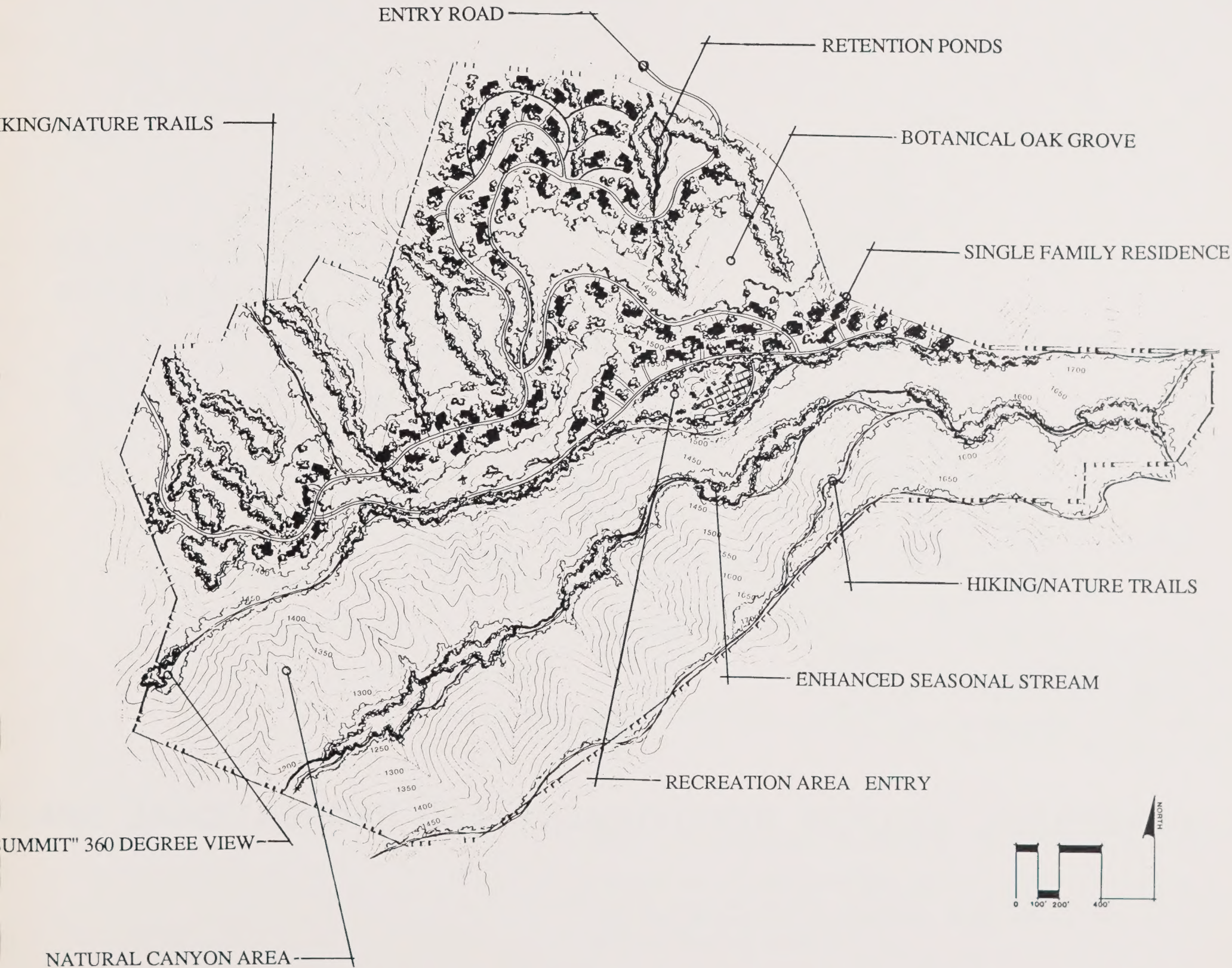
availability of hiking and nature trails.

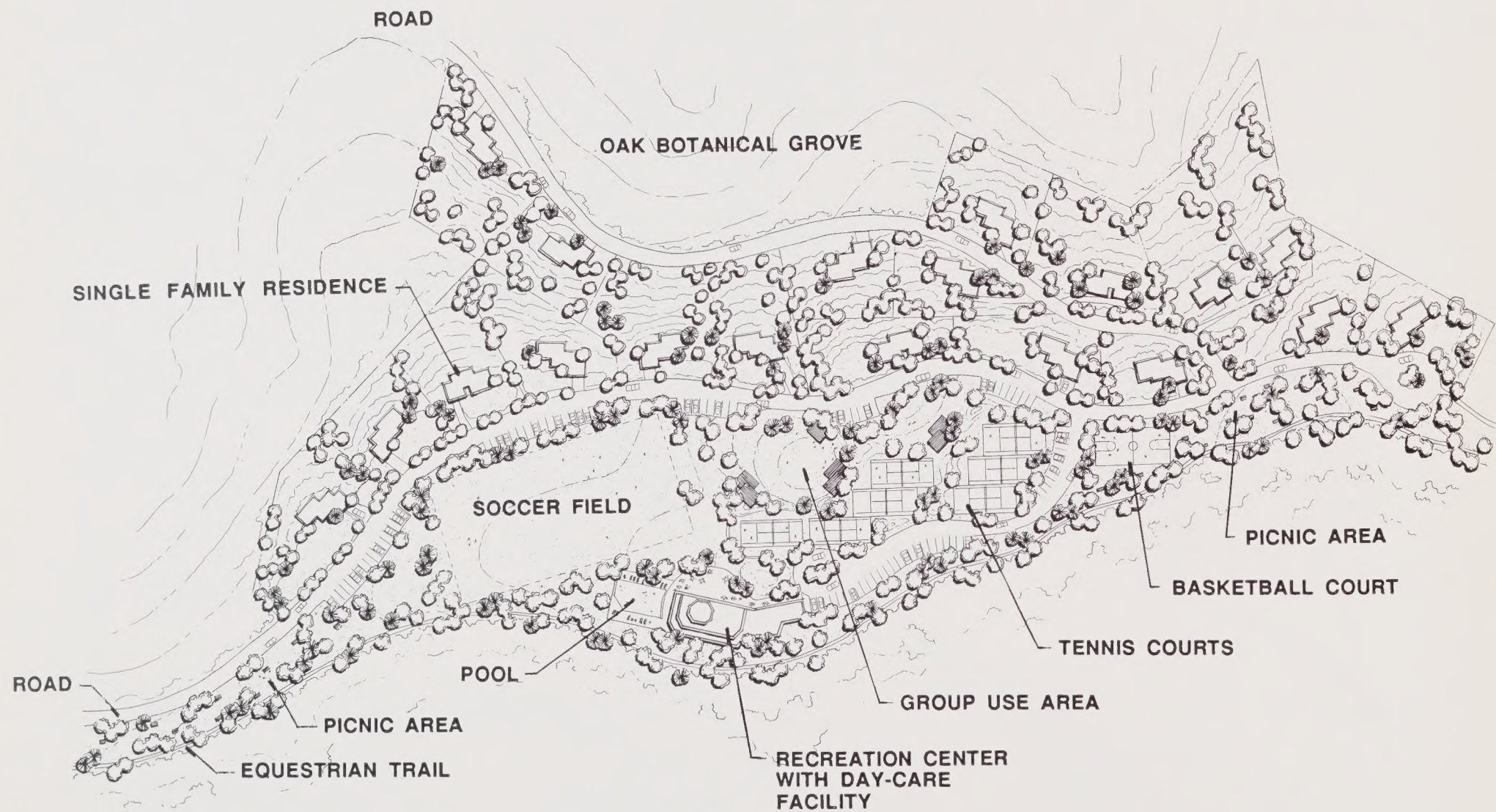
Both on- and off-site views play an important role in the layout and detail of the design. The details of structural design, location and solar radiation are considered to provide a blend of buildings, land, and natural materials. A water reclamation system also aids in the efficient use of natural resources. Open space is a dominant feature throughout the site with the entire southern portion of the project dedicated to the preservation of a natural canyon. Berms of earth and rock provide the seasonal stream



with a riparian atmosphere that promotes moisture retention and results in plant growth and animal habitat formation. This will provide hikers and trail users with an enjoyable experience. Open space is also provided for homeowners in the form of a recreational center located on the unnatural, leveled ridgeline. Residents will be able to enjoy such amenities as a swimming pool, tennis courts and a park. There will also be a magnificent vista of the surrounding countryside.

This alternative blends a single family development and an established equestrian atmosphere with the existing environment and natural features to provide a quality product for a demanding market.





RESIDENTIAL HILLTOP DEVELOPMENT AND RECREATIONAL SPACE

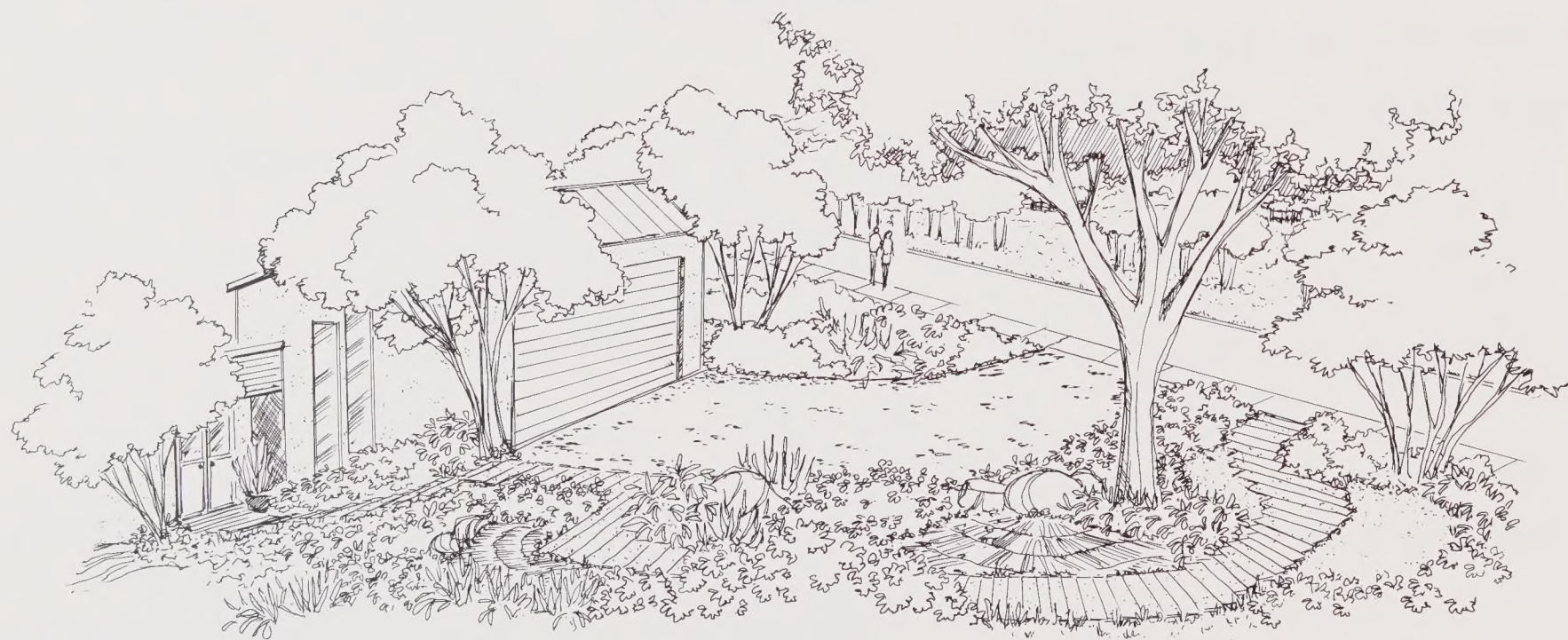


RESIDENCE, SLOPE AND RECREATIONAL SPACE



MC DONALD CREEK ENHANCEMENT

BY THE USE OF MOUNDING AND THE PLACEMENT OF BOULDERS IN MC DONALD CREEK BED, MOISTURE RETENTION CAN BE OBTAINED AND THE PROMOTION OF ADDITIONAL PLANT GROWTH AND ANIMAL HABITAT CAN BE ACHIEVED.



HILLSIDE RESIDENTIAL SPACE

LAND USES					SENSITIVITIES							
AREA	ACRES	RESIDENTIAL	RECREATION	LOTS PER AREA	HYDROLOGY	SLOPE	SOIL	GEOLOGY	BIOLOGY	ARCHAEOLOGY	VIEWS	MICROCLIMATE
1	.5					*			*			
2						*						
3	.4					*		*	*			
4	.5					*						
5	1.7		*			*		*	*			
6	9.3	*	*	15				*				
7	1.4		*					*				
8	0.3	*		2								
9	1.7	*		1		*						
10	2.2	*		5		*						
11	0.9											
12	25.1	*		29								
13	3.5				*							
14	1.0				*							
15	0.7	*		2	*							
16	1.0							*				
17	1.6	*		2		*						
18	1.9	*		1		*						
19	1.6				*							
20	1.4							*				
21	3.9							*				
22	19.4	*		9								
23	1.3				*							
24	1.9				*							
25	1.6	*		5		*						
26	1.1					*						
27	0.7					*						
28	6.3											
29	1.4				*							
30	0.9					*						
31	0.4					*						
32	1.4					*						
33	1.5											
34	1.4					*						



ALTERNATIVE 2

The hilltown concept presents an alternative to traditional hillside development. The plan:

- utilizes hillside guidelines
- remains physically, ecologically and culturally self-sustaining
- addresses the Los Angeles community plans
- proposes appropriate land use
- integrates with the surrounding community.

The hilltown development responds to the communities' plan to maximize individual choice by offering three different types of living experiences:

- condominiums ranging from affordable 1,100 square foot units
- upscale 2,000 square foot units that are intermixed and clustered in groups connected by a series of courtyards and vine covered trellised walkways.
- 1-3 acre, estate lots that will offer low density single family housing. An equestrian facility is also featured which can board and train

horses and store horse trailers.

To preserve the character of the hillside, the development surrounds a permanent open space to allow for planted natural drainage area, trails and a safe place for children to play.

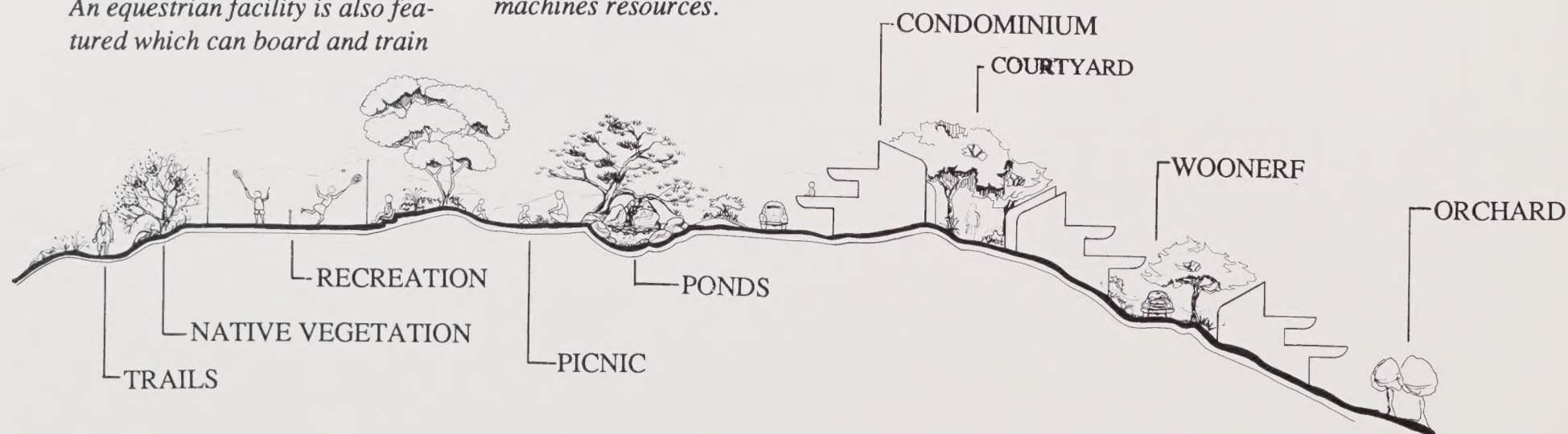
Houses will be sited for maximum solar radiation and designed for solar collecting. An on-site sewage treatment plant will recycle water to irrigate orchards, enhance the riparian zone and provide a fire buffer near structures. Stormwater will be collected into retention ponds to allow water to percolate back into the ground, recharging groundwater resources and relieving overburdened sewage systems.

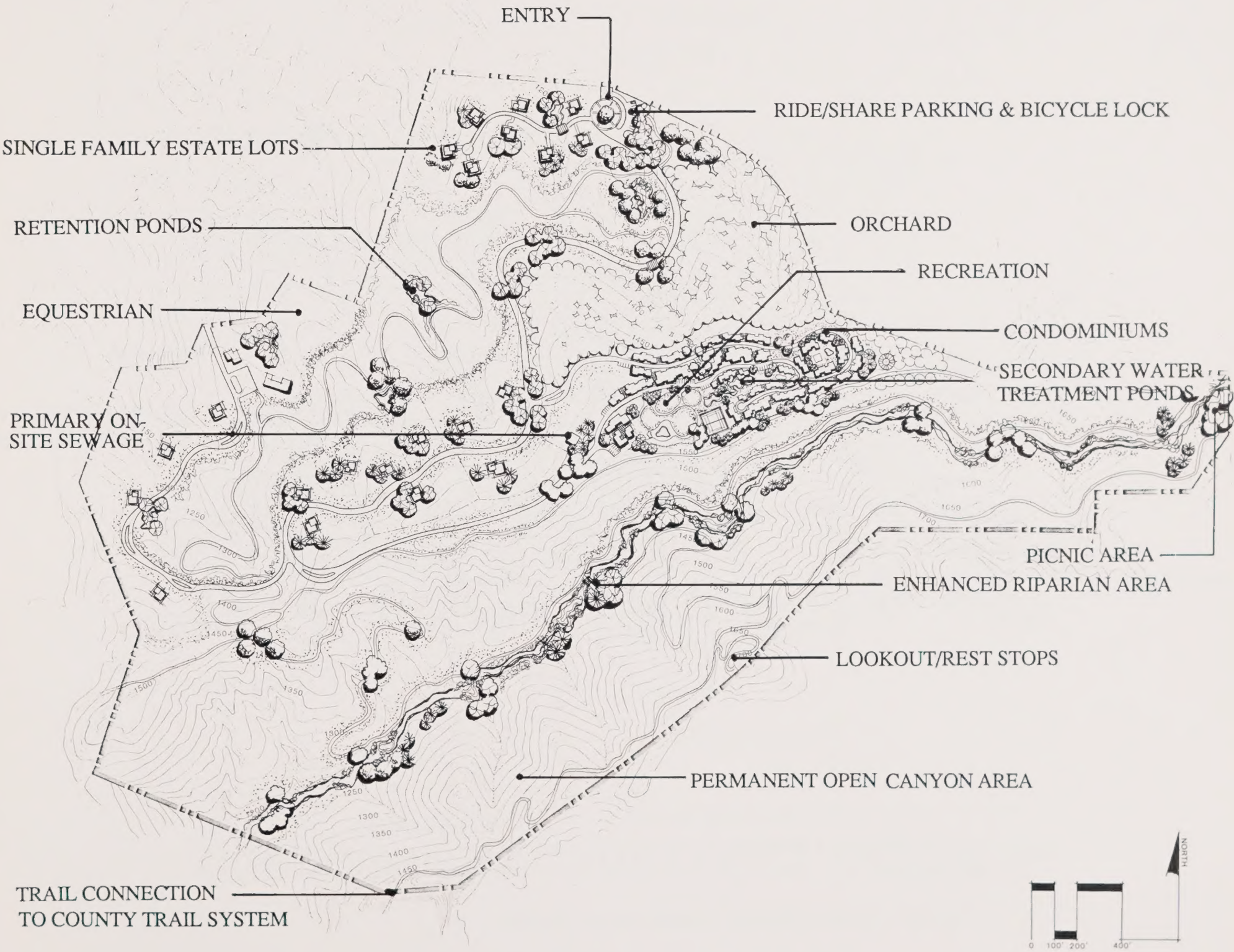
Hydrozoning practices will conserve water and allow native plants to create a natural landscape.

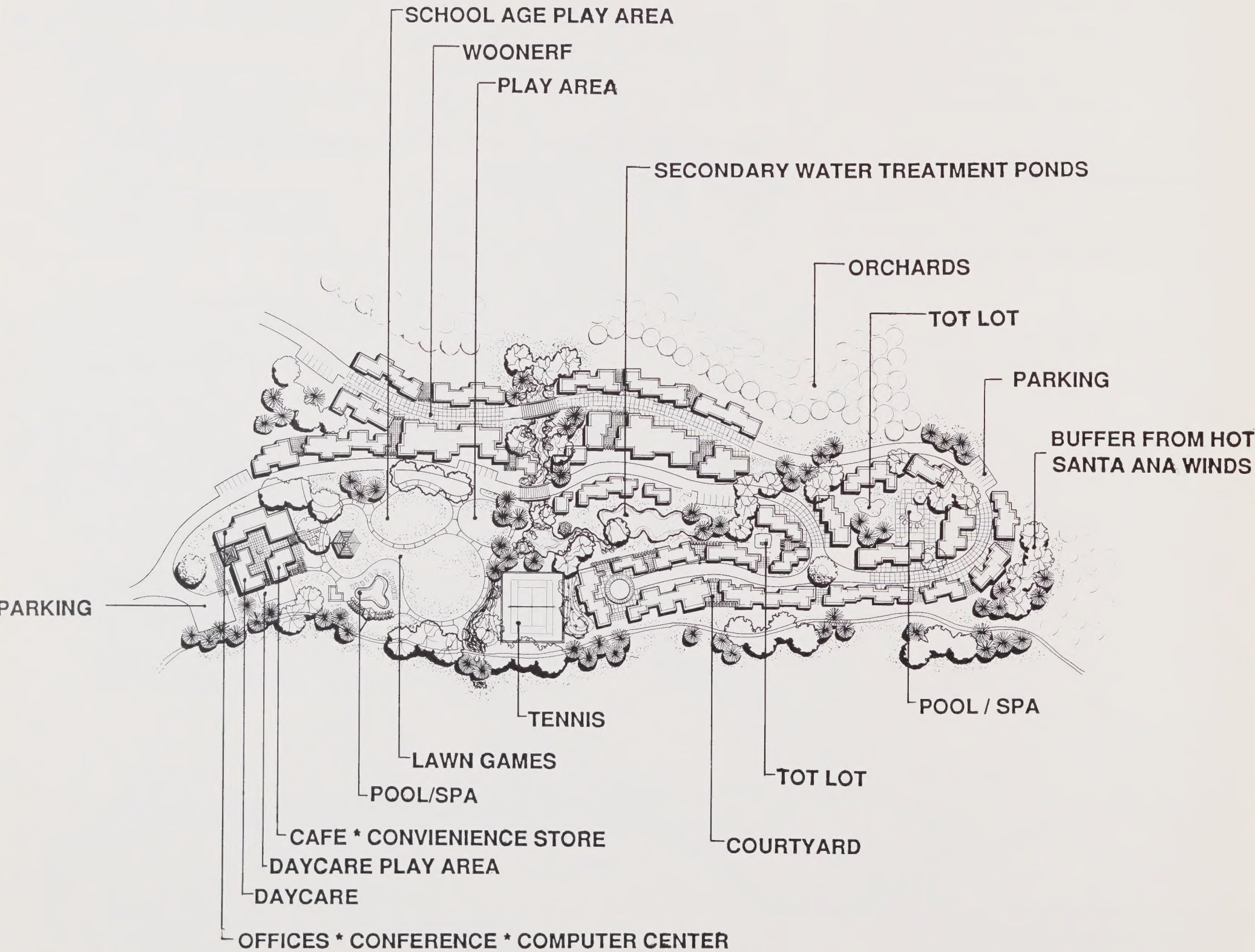
The development will achieve cultural self-sustainability by offering a center featuring a telecommunications network for residents to provide computer and business machines resources.

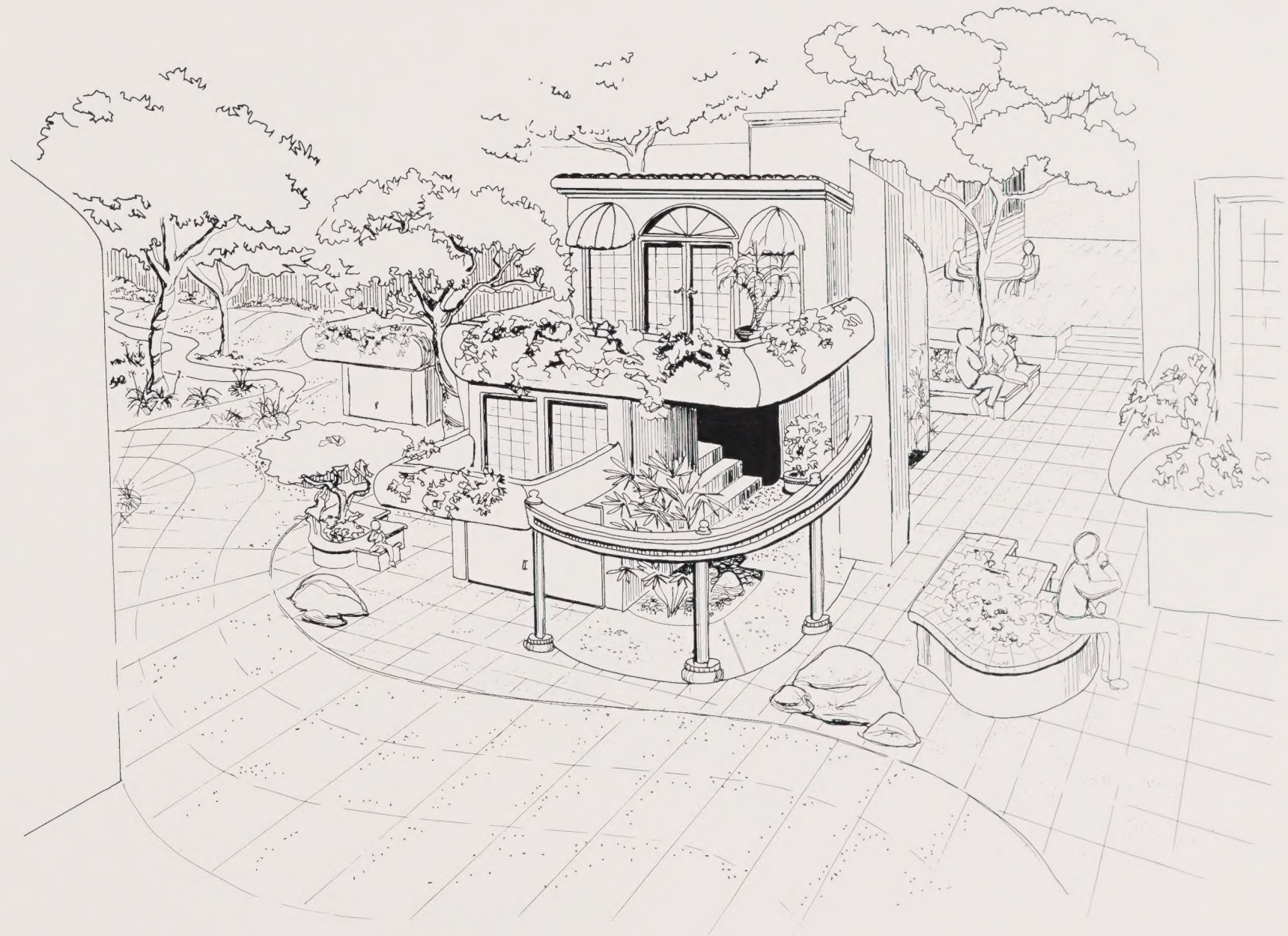
One goal of this plan is to reintroduce agriculture at the village level with orchards and neighborhood garden using recycled water and fertilizer from the sewage treatment plant and equestrian center

The design of spaces plays an important part in the social aspect of the development. Individual patios, clustered courtyards and natural canyons provide a hierarchy of spaces to experience and create an identity at a human scale.









CONDOMINIUM/ COURTYARD/ WOONERF



PONDS

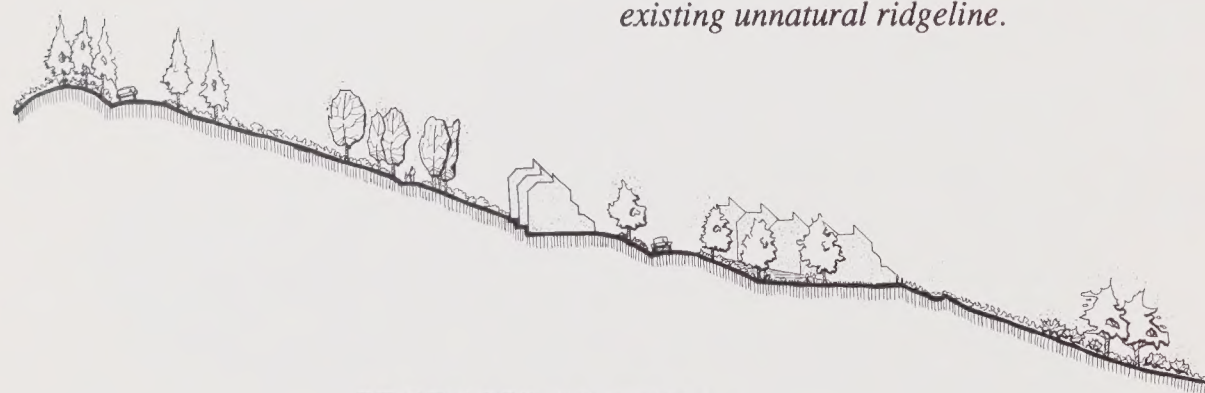
LAND USES				SENSITIVITIES								
AREA	ACRES	RESIDENTIAL	RECREATION	LOTS PER AREA	HYDROLOGY	SLOPE	SOIL	GEOLOGY	BIOLOGY	ARCHAEOLOGY	VIEWS	MICROCLIMATE
1	.5					•			•			
2	.4					•						
3	.4					•		•	•			
4	.5					•						
5	1.7					•		•	•			
6	9.3	•	•	141				•				
7	1.4		•					•				
8	0.3											
9	1.7			9		•						
10	2.2	•				•						
11	0.9											
12	25.1	•		4								
13	3.5				•							
14	1.0	•		2	•							
15	0.7	•		1	•							
16	1.0							•				
17	1.6	•		2		•						
18	1.9					•						
19	1.6				•							
20	1.4							•				
21	3.9							•				
22	19.4	•		8								
23	1.3				•							
24	1.9		•		•							
25	1.6					•						
26	1.1	•		1		•						
27	0.7	•		1		•						
28	6.3	•		1								
29	1.4				•							
30	0.9	•		1		•						
31	0.4	•		1		•						
32	1.4					•						
33	1.5											
34	1.4					•						



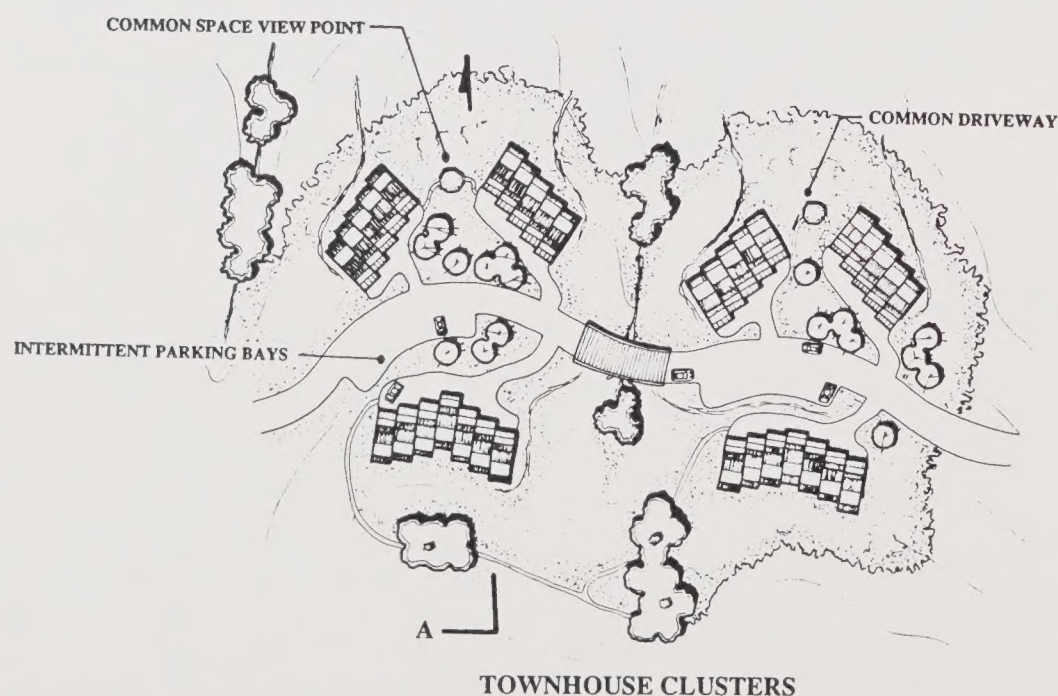
ALTERNATIVE 3

This concept represents a combination of residential examples including clustered townhouse-style, multiple family units and a variety of single family residential units. These single family units consist of clusters, large lots and estate view homes. The goal of this development is to provide a hillside community that creates a natural transition

between the architectural unit and the natural landform by modifying the architecture to harmoniously fit into the land. A unique opportunity to incorporate an active recreation area on the existing unnatural and leveled ridgeline has been provided. Amenities include identifiable neighborhood clusters, houses appropriately terraced into the landform, architecture consistent and harmonious with the natural setting, and clusters united by a linear parkway system that merged at a centralized recreation and equestrian activity node located on the existing unnatural ridgeline.



PROPOSED SECTION A



Other components incorporated in the design concept are:

Circulation

- Minimize length and width of roads to protect the natural setting
- Incorporate the use of common parking and driveway clusters
- Encourage the use of walking and equestrian trails throughout the site

Drainage

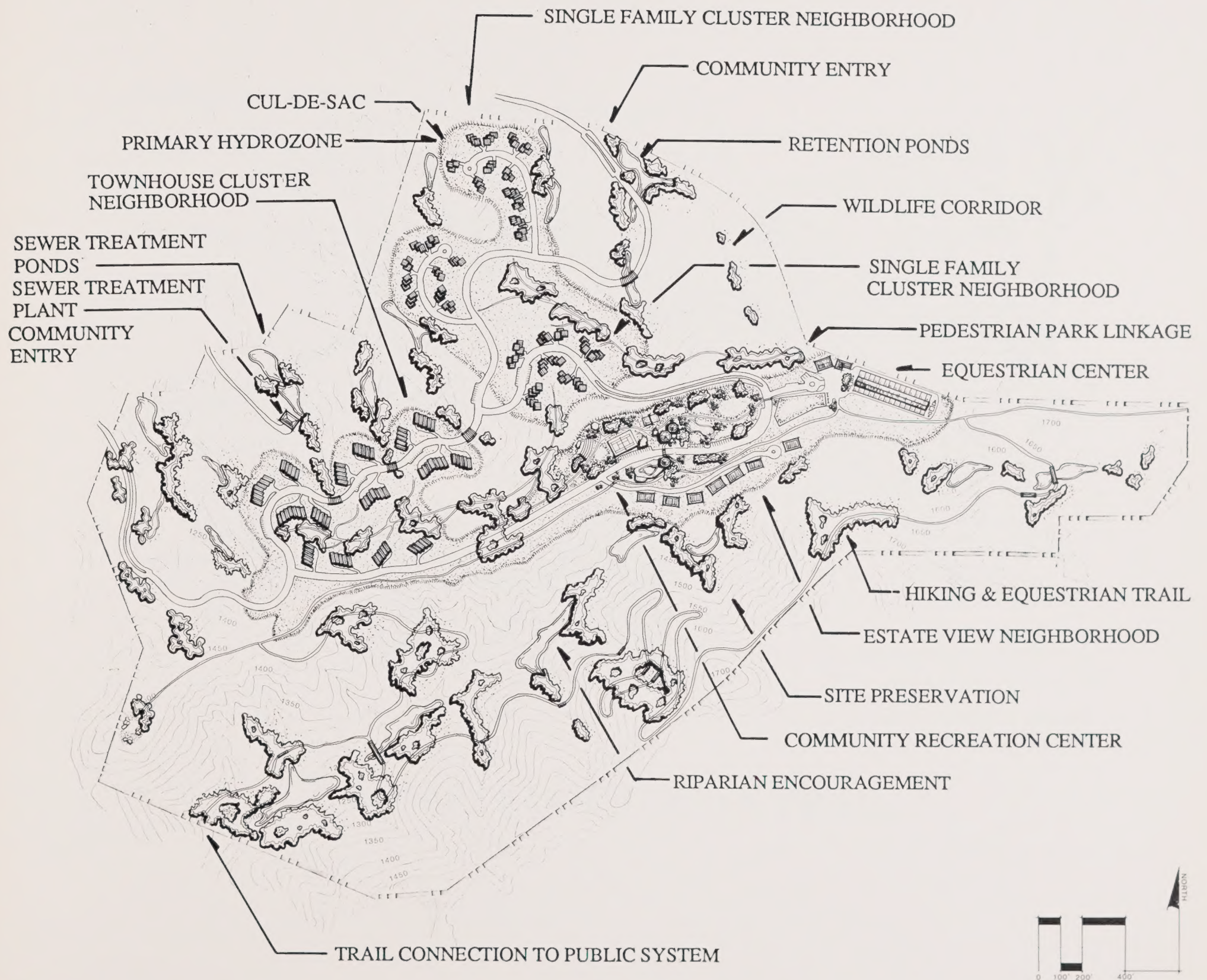
- Control the excess run-off by the use of retention ponds which could increase groundwater recharge
- Encourage riparian growth in the valley areas
- Reinforce zonal planting for fire safety

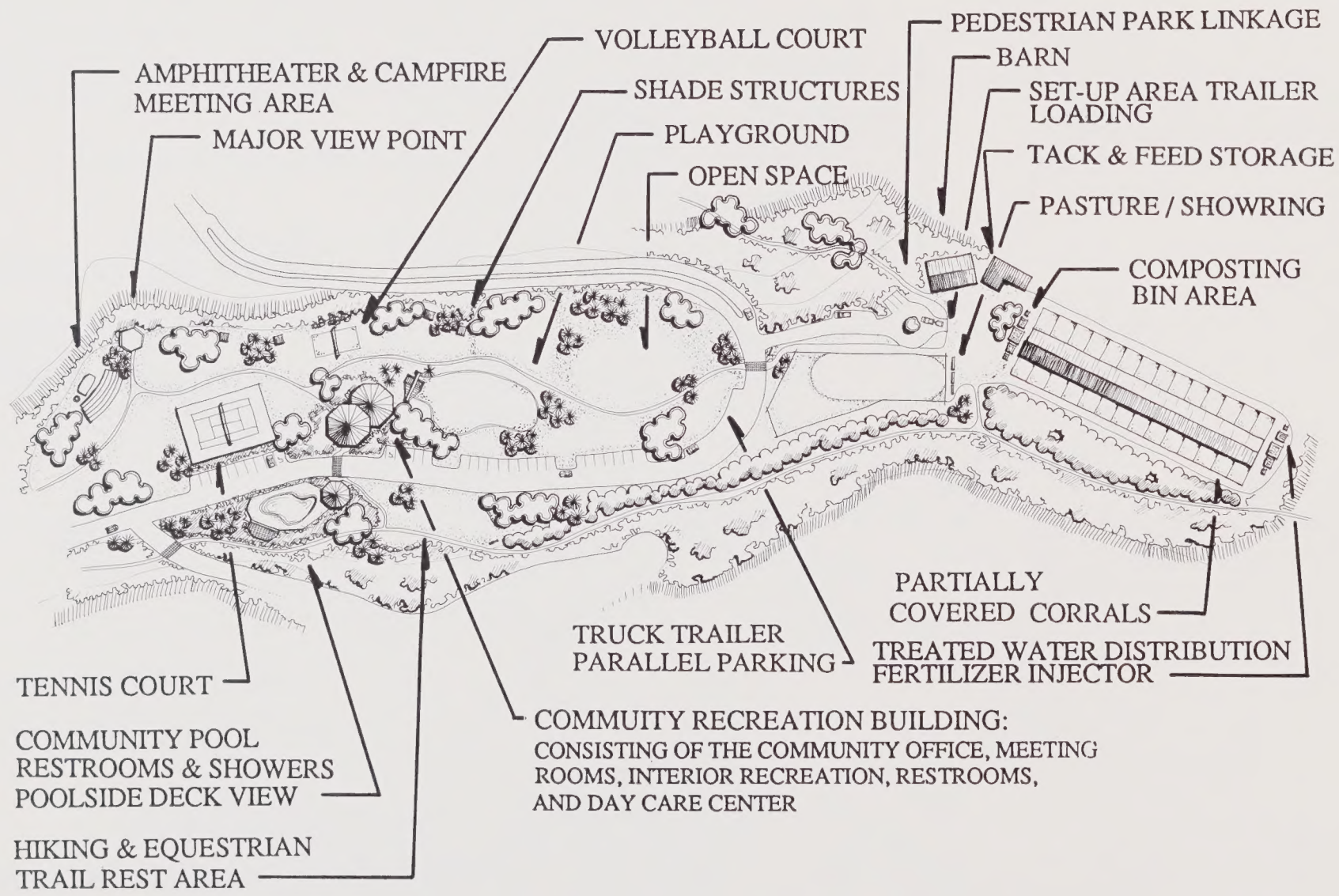
Activity Node

- Incorporate a unique park area and residential equestrian center offering both active and passive recreation with magnificent views

Site Preservation and Enhancement

- Provide the facilities for natural resource reuse such as an aerobic sewer treatment plant
- Emphasize the use of solar radiation
- Encourage the growth of vegetation and wildlife within the preserved riparian and wildlife corridors
- Enhance the domination of open space within the design.







HIKING / EQUESTRIAN TRAIL



TOWNHOUSE CLUSTER & RIPARIAN

LAND USES				SENSITIVITIES								
AREA	ACRES	RESIDENTIAL	RECREATION	LOTS PER AREA	HYDROLOGY	SLOPE	SOIL	GEOLOGY	BIOLOGY	ARCHAEOLOGY	VIEWS	MICROCLIMATE
1	.5					•			•			
2						•						
3	.4	•				•		•	•			
4	.5	•		1		•						
5	1.7			1		•		•	•			
6	9.3		•					•				
7	1.4		•					•				
8	0.3											
9	1.7					•						
10	2.2					•						
11	0.9											
12	25.1	•		29								
13	3.5				•							
14	1.0					•						
15	0.7	•		2	•							
16	1.0							•				
17	1.6	•		5	•							
18	1.9	•		2	•							
19	1.6				•							
20	1.4	•		20				•				
21	3.9	•		58				•				
22	19.4											
23	1.3				•							
24	1.9				•							
25	1.6					•						
26	1.1					•						
27	0.7					•						
28	6.3											
29	1.4				•							
30	0.9					•						
31	0.4					•						
32	1.4					•						
33	1.5											
34	1.4					•						



REVIEW OF DEMON- STRATION MODELS

As a last step before choosing a final alternative the developer is asked to evaluate his alternatives in terms of the demonstration models found near the beginning of the process. These include the hydrology model, the plant and animal model and the long versus short term cost model. Decisions made in this way take into account both the economic and the environmental aspects of design. The developer can then present to the City his first and second choice Tentative Tract Map, confident that the City and future homeowners have been provided with the housing best suited to the unique hillside site.

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APPENDICES

A SURVEY OF ENVIRONMENTALLY SENSITIVE HILLSIDE DEVELOPMENT

LAURIE JONES

As developers begin to understand the new situations created by building on the hillsides, there could be a benefit in having examples available to show how the guidelines expressed in this report may actually be carried out. For this reason I have attempted to locate some of these good examples.

Much hillside development has been done by placing flatland housing on large pads carved out of the hills. To move to an understanding that hillside housing is quite different than traditional housing is an important milestone for developers. Developers do not want to be the first to try a new approach. It is a financial risk they feel they may not need to take. Homes sell no matter how destructive the development is to the land, so innovation is often put aside for the quicker easier, solution. Change is coming about because cities are realizing the importance of their own natural resources. The home-buying public is beginning to accept the new

principles of hillside design and in some cases is demanding changes.

We have attempted to locate and examine a number of hillside subdivisions which begin to solve some of the concerns noted as hillsides are developed. As the survey of environmentally sensitive subdivisions began it became necessary to determine the criteria to be used. How can we judge a subdivision in terms of environmental sensitivity? Toward this end a number of concepts have been selected by which the developments were measured. Rarely, if ever do we find all criteria met in one subdivision. However, when there are many developments that meet few of our criteria, it is encouraging to find some that succeed in several ways.

The criteria used for this purpose include:

- Conscientious slope design
- Appropriate slope planting
- Good drainage practices
- Circulation planned around contours
- Hillside streets as narrow as possible
- Aesthetically pleasing from off site
- Management to control run-off
- Siting of homes to save energy
- Oak tree protection
- Fuel Modification
- Minimum cut and fill
- Minimum desecration of natural landscape
- Berming of daylight cut areas to screen scars
- Retention of wildlife habitat

By presenting examples to developers and to be seen by the decision makers for the city, it is hoped that we can break through the barriers which now encourage the kind of development that is ON the land and not part of it. Hopefully it can be shown that a fit with the land is not only essential to the protection of that land but also pleasing to the homeowners public who will use it.

The following survey introduces four single family and two condominium developments which are the best examples found. Information was gathered from landscape architects, planners, architects, environmentalists, planning departments and builders.

THE AVOCADO GROVE HACIENDA HEIGHTS, CALIFORNIA

This development of single family homes, located off Colima Road, was created out of an old avocado grove. It follows many of the criteria for sensitive environmental design and is, in fact, the best example found in Southern California. Streets are relatively narrow and winding as they follow the contours of the land. Short cul-du-sacs are formed wherever the ground levels out. While there are three exits from the development, two are closed to all but emergency use. Homes line the street in a traditional manner but there the conventional system stops. Almost all homes are multi-level. On one side of the street they step down the hill while across the street the multi-story home sits on a small piece of property at the base of the hill. The amount of grading to create the housing pads and streets is considerably smaller than on conventional sites. In this gated community there are no curbs or sidewalks. Traffic is light because of the gate restriction and there appears to be ample room to walk along the roadside. In spite of the roads following contours there is still enough elevation change so that the location is not conducive to walking or bicycle riding. Arterial roads off-site are more acceptable to joggers and runners.

Drainage is handled by well hidden concrete troughs. There is little visible evidence of run-off into sewers. Occasionally, where a low spot would cause a problem, there is a sewer inlet on the road. There is no evidence of erosion, mud flow or water problems.

As previously stated, graded pad size is kept to a minimum and yards surrounding homes are planted with drought tolerant vegetation. There are virtually no lawns. Native plant material dominates the steep slopes behind the homes and avocado trees remain throughout. Most of the development sits well above Colima Road. There is considerable community land on the slopes leading down to the road. This works well as a wildlife corridor. The development can not be seen from either

Colima or from the freeway below. The tree covered hillside conceals all homes yet gives homeowners a view of the San Gabriel Valley. Most homes are situated on north-facing slopes which is not ideal for energy savings. The fact that most of the trees are evergreen does little to allow the sunlight to penetrate. The atmosphere is rustic and the width of the streets does a great deal to contribute to the rural feeling.



GLENWOOD OAKS GLENDALE, CALIFORNIA

Developed in the late 1950's this subdivision was built into a thick oak woodland in the Verdugo Mountains. Preservation of the trees was tantamount in the design of the subdivision and restrictions and covenants reflect this interest. Houses are built on foundations rather than slabs to protect the tree roots. Swimming pools and spa locations are closely regulated.

Homes are sited around the trees, keeping pad size and grading to a minimum. Some housing pads are below or above street level and some homes have used drought tolerant plant material to compliment the oak trees. Lawns are relatively scarce possibly due more to the heavy tree cover than to environmental concerns. The oaks appear to be thriving and have been inter-planted with many liquidambar

which give the development a comfortable appearance. Houses do not strictly conform to standard siting practices and are designed and built around the oak trees. This gives variety in appearance and allows the homes to fit into the land. Often the building wraps around an existing tree and is so well designed that trees are within several feet of the homes. The fact that this development has existed for quite a few years without apparently damaging or killing the oaks suggests successful practices.

Drainage has been handled in an interesting way. Fed by springs higher up the mountain there is constant, if meager drainage onto the site. At the highest elevations of Glenwood Oaks the creek is natural and winds through the oaks. As it enters the development it becomes channelized. The channel is relatively small -- 8' wide and 5' deep—and exists as an easement between the back property lines of the homes on two different streets. A stock-

ade fence blocks view of both the channel and neighboring homes. However the sound of running water is constantly heard and is very pleasant. Rocks in the creekbed accentuate the sounds. What might have been a visual problem was made into an appealing feature. There is a second channel which has not been camouflaged and is not nearly as appealing. It is at the very edge of the development and may not be part of it. It would be a recommendation to the city of Glendale that they upgrade the visual quality of that channel.

Contrary to present day fire practices there is only a single entrance to the development. A fire road winds out of the tract into the mountains. It follows the creek, is lined by oak trees and creates a wonderful inviting recreational trail. There are approximately 75 homes in the subdivision. Roofs appear to have been shake singles originally but have, in many cases, been replaced with fire-resistant materials. Although it is bordered on the north and west by Honolulu Boulevard and the entrance ramp to the 210 freeway, and on the east and south by Crescenta Valley Park, the subdivision gives the feeling of remote country living.



GLEN KNOLLS GLENDALE, CALIFORNIA

This development is new with some homes still being built. It gives the feeling of high priced urban living. Trees are not natural to the site. Plantings have not developed enough to soften the structure lines but there are some environmentally sound practices being carried out on site. The ridge line has remained untouched and home-sites are located well below the ridge on roads that generally follow the contours of the land. A fire road leads up to the ridge and links to recreational trails. A vista point would be appropriate on the ridge. Lots

are not large and the developer took advantage of some semblance of cluster housing by using shared driveways and siting homes along existing contours. Grading for homes is still evident and architecture reflects flatland development. Views were protected in many cases and the appearance from offsite (Verdugo Rd.) is one of minimal destruction of land. The prominence of the ridgeline keeps a natural appearance to the site. Once trees have time to grow the development will blend well into the land. While one or two palm trees were evident, more natural appearing exotics such as eucalyptus and pine were generally used.



PORTOLA VALLEY RANCH PORTOLA VALLEY

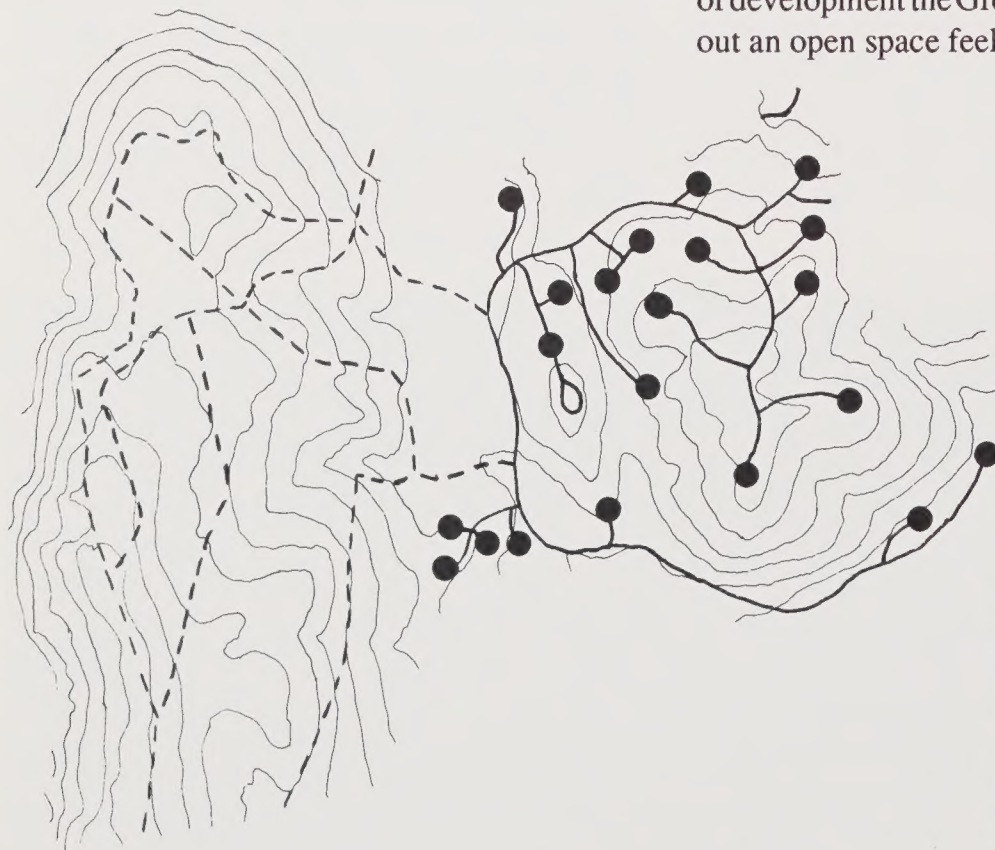
Portola Valley Ranch is a 450 acre planned community in Santa Clara County hill country. The oak woodland location provides a magnificent site for development. Situated in a town determined to provide a rural atmosphere, the development was planned for clustered housing surrounded by shared undeveloped space for all residents. The oaks dominated the planning process and remain the most significant feature of the site. Nature preserves and hiking and riding trails separate the clusters of homes and are managed by the Ranch Homeowners Association. Each cluster is planned so the homes, roads and water systems work as an interrelated entity. The ridge lines are preserved, houses are sited for solar access and views are protected. The arterial road through the development follows the ridgeline so that minimal grading was required. Pathways con-

nect the clusters and 17 miles of trails criss-cross the 450 acre property. There is constant interaction between the ecosystem and the homeowners to ensure that the needs of each is met. This site has become a prototype for environmentally sensitive development. Guidelines have been written covering such areas as soils, oak woodlands, grasslands, watersheds, animals and viewsheds. It should be noted that watershed management has led to significant water conservation. This, especially, has brought support from the planning commission. Such things as curbless roads, permeable surfaces and erosion control guidelines are important parts of this development.

THE GROVE AT SCRIPPS RANCH SAN DIEGO, CALIFORNIA

This condominium development was created among a eucalyptus grove on the hill-sides east of San Diego. The buildings are of one-level unobtrusively set into the hillside. On the downhill side the buildings are held up by posts creating a space below. This space is clear of vegetation for fire reasons. Fuel modification practices are observed on all slopes and a combination of a thick eucalyptus cover and drought tolerant plantings make the condos blend quietly into the land. The effect is quite pleasing. In an area where there is a great deal of development the Grove has managed to carve out an open space feeling around it. Roads go

behind the layers of condos on the uphill side. They are narrow and have no sidewalks or curbs. Each road reaches a dead end but the distance is allowable as a cul-du-sac. It appears as through the turning area at the end could give fire departments trouble, but the short distance makes it acceptable. Buildings focus out to the front so the road acts more as an alleyway. Very quickly residents and visitors are taken from this roadway and moved into spaces that appear far more natural. From inside the homes only the natural eucalyptus grove can be seen and the unit becomes an extension into the landscape. There are pathways meandering through the grove to aid in circulation between the units. To have put traditional single family homes on this site would have taken considerably more grading and denuded the area of its wooded atmosphere. Natural drainage is maintained in most situations but sewers on each alleyway keep erosion from becoming a problem. Since the cut slopes are located under the buildings there is no need to landscape them. Surrounding eucalyptus provide plenty of foliage to the land.



CHEVY OAKS GLENDALE, CALIFORNIA

This development is very similar to the grove at Scripps Ranch in San Diego. A condominium group nestled in a grove of eucalyptus trees. The layout is a little different and the homes are more traditional looking - they do not fit onto the hillside as well and larger pads were needed. All homes are below the ridgeline and views are protected. From off-site the project is hardly seen as it clings to the side of Chevy Chase Canyon. When Chevy Oaks was built there was a tremendous seeding of eucalyptus. They grew so thickly that the homeowners group which manages the land has had to severely thin the stand of trees. The development has a single access road. From that road several cul-du-sacs lead off to the clusters of condominiums. Fire regulations would have some difficulty with the plan. Additional site planning perhaps could have created an access trail which would have a dual safety and recreational purpose.

SILVERADO NAPA COUNTY, CA

The Silverado Community, located in Napa County is comprised of residential, recreational and commercial development.

Elevations rise from 50 feet to 1100 feet. The Valley is a riparian area, bright green and lush. The flat land includes recreational and residential area, where vegetation is strongly man-controlled. The hills, mostly residential, are brown and dry. Oaks stud the hillsides which have been kept natural. The canyon is wild, steep and natural.

The valley floor offers a golf course, fairway homes, resort center and shopping on the valley floor. The club house is a previously owned estate house built in the southern colonial style and lush with Mediterranean vegeta-

tion. Houses are situated in tight clusters around cul-du-sacs. The main road makes a formal entry through the green valley and into the brown natural hills studded with oak trees. Trees not only define the fairway, but act as protection for houses located on tight clusters nearby.

A stream has been developed to control erosion in the valley area. Drainage from higher locations on the site provide water. The hills contain a residential area of varying density, from large single family lots to high density, attached hillside dwelling units located on cul-du-sacs. Views are considerable, both off-site and across the canyon to the ridgeline beyond.

Roads follow contours as much as possible to keep an acceptable grade and reduce the cut and fill. Often split roads have been incorporated to take advantage of the topography. Where this occurs, heavy tree plantings fill the dividers. Roads are kept narrow to reduce run off and add visual character. Sidewalks are on one side of the road only. Houses are sited with



the contours to reduce grading. Two story homes reduce pad size and lend balance to the trees on the slopes. Built of natural materials, they blend well with the land and often are hidden among the trees on the slopes. Built of natural material, they blend well with the land and often are hidden among the tree masses. Structure setbacks on lots vary to take advantage of the topography. The steep slopes in the areas contain trees, but no houses.

This development is different than the others because of the sharp contrast between the natural and ornamental landscape.

It is hoped that more examples of well designed development will soon be found in California. Each built example offers a verification to both developers and homeowners of the numerous opportunities found in environmentally sensitive design.

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DRAINAGE AND GRADING FOR HILLSIDE DEVELOPMENT

By DAVID LEMIEUX

DRAINAGE

Current practices in storm water drainage in residential hillside development are in need of environmentally sensitive revision. These practices have emphasized the rapid removal of storm water from a site, usually into catchments for underground systems. There is little or no recognition of downstream effects

The effects of these approaches has led to increased frequency of flooding and to the diminishment of groundwater supplies. In the past 30 years, downstream flooding problems have become acute as larger residential communities have grown and as curbed roadways and paved channels have been installed in areas which formerly provided run-off recharging storage in natural swales or ditches. The final results are very large investments to construct additional flood control projects. Where this is infeasible, the flooding hazard reduces property value and leads to possible abandonment of lands.

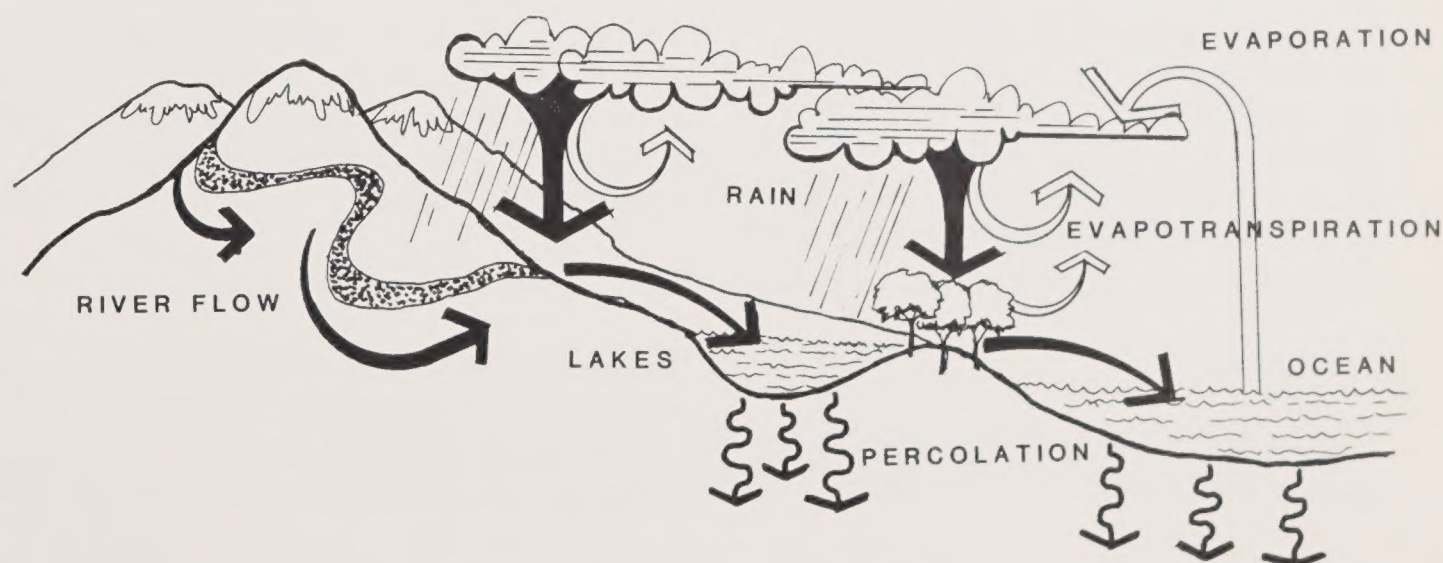
Stormwater run-off drainage practices need change, evidenced in part by increasing emphasis on storing runoff on site. Site storage, applied to residential hillside development, will have beneficial effects by helping solve both peak run-off and short term run-off. These storage techniques would reduce major facilities investments required to protect against flood hazards in hillside development.



THE NATURAL HYDROLOGIC CYCLE

In natural hillsides areas, the cycle begins with the interception of some rainfall by plants. Some of this water directly evaporates, some remains on plant surfaces (leaves and stems), and some falls directly to the surface or falls from the plant surfaces to the ground. Still other parts of the storm water percolates deep into the ground and replenishes the ground water supply. The remainder of the water gradually or quickly collects,

accumulating both in quantity and speed as it goes down the watershed through natural drainage ways such as valleys and streams, and ultimately goes to its destination, out to the rivers and eventually into the ocean to begin the cycle all over again.



THE PROBLEM

Natural drainage channels are not static, but are moving streams and water ways constantly changing their courses. The banks erode, vegetation changes with seasons, lakes fill with sediments and disappear, and river flood waters rise above their banks and inundate surrounding lands.

As land is altered by man, natural drainage patterns are changed and require expensive constructions to prevent flooding. This requires drainage techniques other than those of the natural flow process so as to protect structures and land from flooding. These man-made systems are expected to remove run-off as quickly as possible. The result is an imbalance to the hydrologic cycle.

There is a need to strike a realistic balance between the need for flood protection and the positive aspects of natural drainages—groundwater recharge, retention of riparian vegetation, creation or preservation of wildlife habitat, retention, high visual quality, etc. Designs that incorporate these features will include rooftop ponding, parking lot ponding, percolation storage, lakes and ponds, open channels and swales, and blue-green storage. Blue-green storage is basically a potential overflow area for water runoff. During the wet seasons, the area will retain the storm water sheet flow to slow down the runoff (blue). During the dry seasons, the area will be left as natural open space for aesthetic visual quality and potential recreation (green).

CONCEPTS

1. Runoff on a given site is absorbed and retained on site to the extent that, after

development, the quantity of runoff leaving the site is not significantly different from that which would occur if the site had remained undeveloped.

2. Optimum design of storm water collection, storage, and treatment facilities should strike a balance among capital costs, operation and maintenance costs, public convenience, risk of significant water- related damage, and environmental protection and enhancement.

3. Emphasis is placed on application of natural engineering techniques as well as man-made structures (where natural would prove to be unsafe) so as to preserve and enhance the natural features of a site. These techniques would maximize economic-environmental benefits consistent with natural resources and processes.

4. Use is made of on-site detention and retention structures to control site runoff and to enhance groundwater recharge. Retention structures are used where percolation will effectively contribute to site, area, or regional groundwater resources.

5. Site design is prepared with recognition of the part each site plays in regional drainage and water resources. Highly engineered solutions which seek to rid the site of water without regard for downstream or on-site effects are to be avoided.

OBJECTIVES

-To provide a clear understanding of residential storm water runoff systems, including their intended functions and impacts of alternatives on the design and effectiveness of

present and alternative systems.

- To provide methods for determining the analysis necessary to derive the optimum design solution.
- To provide guidance towards identification and selection of alternatives solutions to drainage which utilize and preserve desirable existing natural and standardized systems.
- To encourage the design of systems which will minimize potential erosion and sedimentation problems.
- To encourage the design of systems which respond to the needs of natural areas, and to maintain or enhance ground water resources, including ground water quality, except where land stability might be impaired.
- To encourage the design of systems which will reduce capital and environmental costs to the community.
- To encourage system design which will conserve as well as preserve on- site unique and natural features.
- To encourage continuous improvements to regulatory practices and policies at all levels of government.

STORAGE

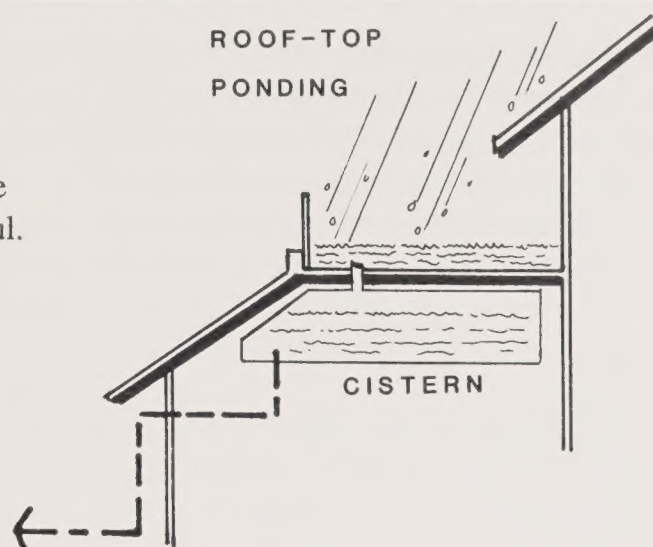
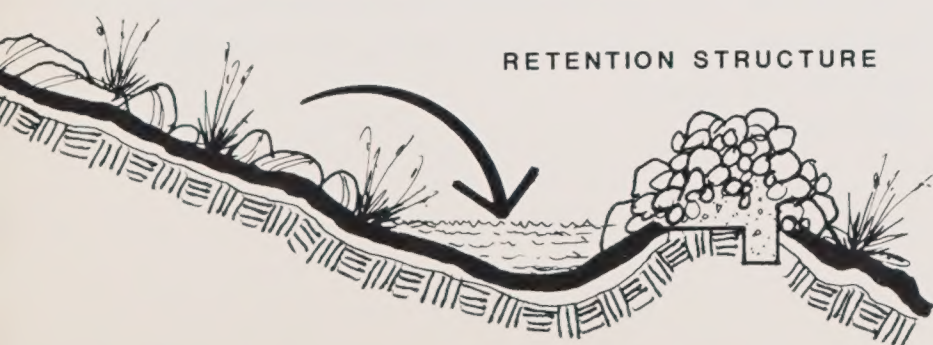
The design of permanent and temporary ponding and/or storage should be an integral part of the overall development planning process and should consider opportunities for the creation of such facilities within the open space and landscaped areas.

Storm water runoff systems should be designed to facilitate aquifer recharge to compensate for ground water withdrawals. Designs should be carefully analyzed where the effects on groundwater might be harmful.



Design of permanent storage facilities should consider safety, appearance, possible recreational use and effective, economical maintenance operations in addition to the primary storage function.

Natural open spaces can enhance entire neighborhoods rather than just the adjacent properties. Potential overflow areas should be developed as open green spaces. Retention structures—percolation basins, lakes, or ponds—are best located in these areas. There is a range of degrees of storage that varies with the types of structures or landscape features that can intercept rainfall or runoff.



DEGREES OF STORAGE

Rooftop ponding

The structural capability of roof systems must be considered when designing for runoff. Overflow mechanisms should be provided so that there is no danger of overloading during major storms. For example, A 3 inch water depth is equivalent to a load of 15.6 lbs./sq. ft. which is less than most current building code requirements for live loads.

Water will be detained for a significant amount of time on the roof for slow down of runoff period peak and also for the chance of evaporation into the air.

Parking lot ponding

Parking lot ponding should be arranged so that pedestrians can reach their destinations without walking through ponded water. Ponding should be in areas farthest from the high use areas or in overflow parking areas, and should be a reasonable portion of the total area so as not to impact normal parking. Maximum design depth of ponding can vary according to location. For example, A 7 inch design depth is considered reasonable where access to parking will not be impaired. Overflow outlets and proper maintenance of the outlets should be considered in order to keep the maximum depth of the water within the parking area. Lastly, thought should be given for the use of semi-paved/semi-grassed areas for overflow parking which will permit infiltration of rainfall and reduce the total runoff associated with parking lot pavements.

Percolation storage

Under favorable conditions, runoff may be discharged into trenches back-filled with sands and gravels chosen and placed in accordance with sound graded filter principles. This system will accomplish both the disposing of part of the storm water and the recharging of ground water storage. An overflow channel should be provided to carry off excess storm water when the percolation trench capacity is exceeded. Under appropriate conditions, piped storm drains can be open-jointed or perforated to permit exfiltration.

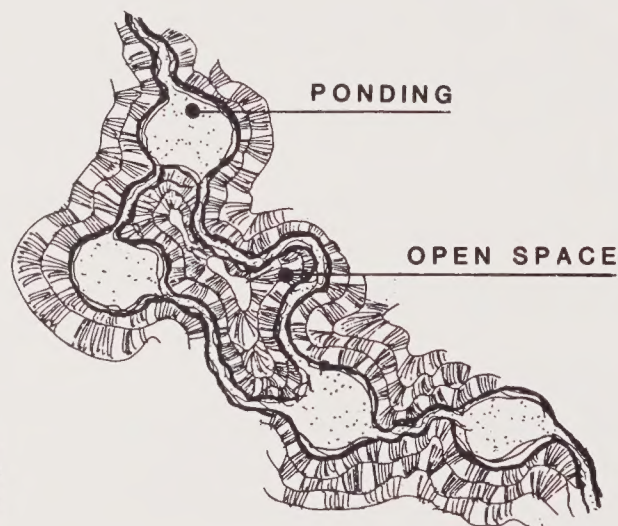
Lakes and ponds

For major installations, stream flow measurements in advance of the planning stage may be desirable. The retaining structure,

usually an earth dam, must be designed and constructed according to the best accepted practices for such structures.

Lakes and ponds provides maximum amounts of storage with the greatest benefits including short and long term enhancements of property values and the landscape; possibilities exist for boating, fishing and swimming; and habitat for resident and migratory wildlife is created. Lakes and ponds must include an overflow spillway to handle potential peak runoff from major storms so as not to cause serious damage to adjoining properties and a means for draining the lake or pond must be provided.

point on the embankment face, where approach velocities become significant, to below the downstream toe of the embankment. Such dams may be used as a chain of lakes that provide focal points and enhance long term neighborhood values and stability.



-Natural overland flows and open channel and swale routings should be the preferred major components of a residential drainage system.

-Open channels and swales should be routed and designed to avoid or minimize safety hazards.

-Alignment of a drainage system must be coordinated with the design of lot and street patterns and grades.

Sheet runoff

In planning a sheet runoff system, overland flow distance should be made as long as possible. Overland flow should be over and through turf materials or other flow retardants such as ground cover or forest litter which helps in slowing the velocity of runoff. Minor surface depressions due to the irregularities of landform grading add further to the storage potential and the slowing of runoff.

For residential hillside development, flow velocities for erosion potential evaluations should be based upon the ten-year-frequency runoff event, which generally is a practical break-point between initial cost and excessive maintenance cost. When dealing with runoff flow velocities, there are two major designs used to carry the water to designated areas. They are: swales and minor channels and major channels.

Swales and minor channels

When runoff reaches the swales and open channels of smaller proportions, principles similar to those for overland flow should be applied.

Open channels (Natural Drainage)

Natural drainage flow techniques serve very useful functions in the control and management of storm water runoff. The primary function is to provide an opportunity for natural infiltration of storm water to the ground water supply system.

Secondly, it helps to control the velocity of runoff flows, which is a necessary factor in the control of erosion and sedimentation.

Thirdly, and perhaps most important, natural drainage techniques can extend the time of concentration of storm water runoff, thereby contributing to the ultimate goal of maintaining the rate of runoff at or near the levels existing prior to development:

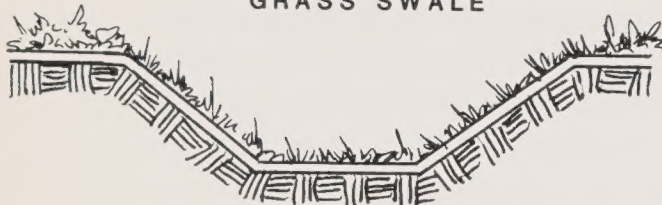
The design of storage facilities to meet these criteria requires the services of engineers experience in hydrology, hydraulics, and earth structures. Aesthetic considerations suggest that there is value in using the services of a landscape architect.

Street intercepts

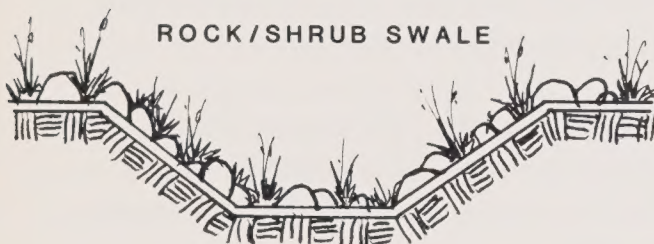
Where streets must cross drainageways, there is an opportunity to utilize the roadway embankment as an effective detention dam. Such dams are an integral part of the blue-green development approach. The entire roadway and embankment may serve as the overflow spillway. This necessitates continuous erosion protection from the upstream

Where feasible, the channels and swales

GRASS SWALE



ROCK/SHRUB SWALE



should be wide and shallow with a rough surface so as to further reduce runoff at peak flows. Slopes should be maintained so as to bring about optimum conditions for water retention.

The Manning Equation is almost universally used in calculating open channel flow since velocity of flow in open channels and swales is dependent on rate of flow, slope, surface roughness, and cross section area.

$$v = \frac{1.486r^{2/3}s^{1/2}}{n}$$

Where v is the velocity in feet per second, r is the hydraulic radius in feet, s is defined in energy losses in open channels, and the constant 1.486.

Surface roughness and consequent velocity will depend on the quality of maintenance. Well-mown grass will have a different surface roughness coefficient than tall grass. It should be noted that the quantity of water which can be carried in well-established, dense turf swales without erosion is surprisingly large, even for steep slopes.

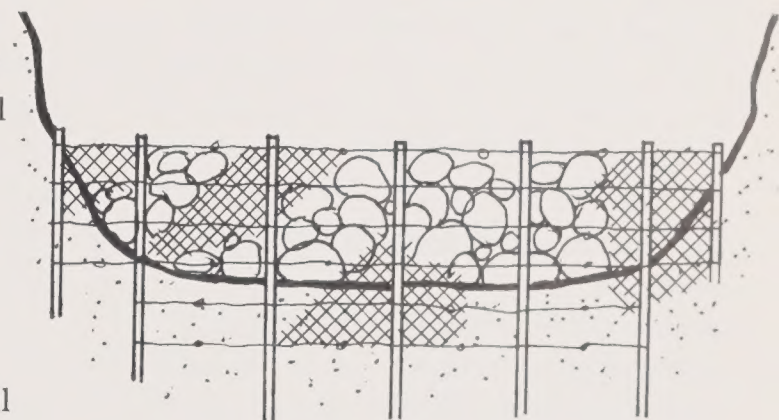
When the allowable velocity for a turf channel is exceeded, major channels are needed. There are a number of alternatives to consider. They include: lining channels with an impervious material; drop structures or other velocity and erosion control measures; gravel or rip-rap bottoms; and gabions (rock enclosed in wire baskets). The following are descriptive of surface treatment techniques for major channel alternatives:

Major channels

1. Porous concrete, asphaltic concrete, or soil cement paving—permanent if carefully constructed and maintained. High cost and speeds up runoff.
2. Drop structures across the channel at intervals so that the slope of the channel between drops restricts velocity on turf—satisfactory if drops are well-designed and built. Does not speed up runoff. Unsightly if natural materials are not used. May have maintenance problems.
3. Lining with crushed rock or gravel sized for anticipated velocities —satisfactory if well designed. Can harmonize with landscape. Can allow both infiltration into permeable soil and exfiltration of ground water. Can be costly if not available locally.

4. Rip-rap—permanent if carefully placed and maintained. Can be costly and can be unattractive.

5. Rock enclosed in galvanized wire baskets (gabions). This requires wide shallow channels so that drops will not be over-ridden and channels destroyed during extreme flows. Permanent if carefully placed. Can allow infiltration on permeable soil. Can be costly. Aesthetically pleasing and becomes invisible.



No limit to range of flow velocity.

Natural streams

Maintenance of streams in their natural condition is a desirable goal. Natural streams are not only self sustaining in terms of energy, but also provide natural wildlife habitat and vegetation for aesthetic quality. In terms of cost, natural streams can provide the same means of collection and transport of water runoff as underground pipe systems, but at more than half the cost. Limiting the minor storm discharge from hillside residential development is a means of controlling the peak discharge.

The two concepts, storage and the use of natural open channel flow, assist in this objective.

UNDERGROUND PIPE SYSTEM

The use and layout for storm drain systems for hillside development areas should make the use of existing open channels and natural stream systems, and of storage recharge techniques before using the enclosed runoff systems of underground pipes. At present, overuse of the closed systems is not only expensive, but also concentrates the flow downstream and increases the peak rates of discharge.

The preferred approach is to leave natural streams undisturbed and to limit peak runoff conditions wherever possible. Erosion of stream channels usually is not accelerated when this is accomplished. Overall, runoff will be collected in swales or open channels and in gutters and carried as far as practical, passing over and through the storage areas for recharge. Any excessive water which has not been trapped, percolated into the groundwater aquifers, or diverted to retention ponds for aesthetic and recreational uses will finally be channeled into underground standardized pipe systems.

The underground pipe system can be used as a back-up alternative when on-site runoff exceeds the capacity of natural drainage systems.

OTHER DESIGN CONSIDERATIONS

Soil erosion: Control of erosion during residential construction requires thorough

site analysis to show potential erosion problem areas, such as steep slopes, highly erodible soils, and natural drainage areas. Erosion control measures should be taken to protect against hazardous problems in these critical areas. Control of erosion after construction should include proper maintenance of the drainage areas and repair of the drainage systems. Some of the basic concepts for controlling erosion during and after construction are:

Earth slopes: Protection of slopes in both landform and standardized grading practices should be established immediately by vegetative cover, benches, terraces, slope protection structures, mulches, natural controls, and the combination of several or all of these techniques.

Waterways or channels: These structures should be designed and maintained to avoid serious erosion problems. Wide channels lined with grass or other vegetation should protect against erosion. Where channel gradients are steep, linings or grade control structures may be required. Linings may include stone or concrete, but every effort should be made to preserve natural channels.

Existing vegetation: Healthy stands of existing vegetation should be preserved in the initial planning stages of a development for added control of runoff and erosion.

Outfall design: The design for the pipe should be done so that the area used by this system minimizes erosion; especially if the outfall is overland flow area with steep slopes or above the base flow of the receiving

streams. Energy dissipators may sometimes be necessary.

Temporary ponds: To store the runoff during construction and allow suspended solids to settle. This system may also be retained as part of the permanent storage system after construction.

Hay bales: Existing inlets to underground pipe systems can be protected from debris build-up by use of hay bales placed in strategic locations near the inlets.

Egress points: These areas from construction sites should be controlled so that sediments are not carried off-site by construction traffic.

CONSIDERATIONS

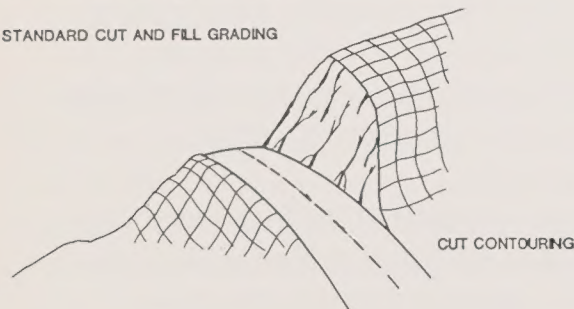
Some communities have established special assessment districts or storm drainage fees for the purpose of constructing drainage improvements. The basis of the fee may be the difference between the amount of runoff which is generated from the property in its developed condition as compared to the amount generated in its natural state. If the same amount of runoff has been maintained by on-site ponding or other means, the fee may be negligible. If, on the other hand, the natural permeability has been reduced by extensive paving, the property may be subject to high drainage fees. Also, the fees may reflect the cost of flood control works which are necessary to protect the property.

GRADING

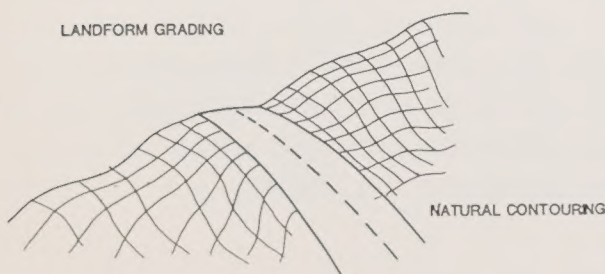
During the planning and design process for a residential development in a hillside area, a soil and geological investigation of the site should be performed first. This survey will indicate limitations for the placement of structures and grading practices, and may indicate areas needing restoration or stabilization. Some common soil-related limitations, in addition to erodibility potential and stability, are poor soil drainage, high shrink/swell potential, shallow bedrock, low strength, corrosiveness, and compressibility. Information from soil surveys does not eliminate the need for on-site studies of detailed soil conditions and characteristics, and of such potential problems as landslides, flood hazard exposure, or exposure to a variety of other geologic hazards.

Soil erodibility, stability, and the planting layer is a major consideration in the selection of the type of grading techniques to be used. The two major types to be discussed will be that of standard cut and fill grading and that of landform grading.

STANDARD CUT AND FILL GRADING



LANDFORM GRADING



The most important steps in deciding which type of grading technique to use follow. These steps should be carried out to an extent appropriate for the site and should be followed through the site design and construction processes:

- Study the site and surrounding area and assess soil limitations and suitability of the site relative to the topography, geology, natural drainage, hydrology, prevailing winds, solar access, and other factors.
- Identify potential problem soils, if any.
- Select forms of construction that will be compatible with site conditions.
- Examine existing and proposed drainage patterns
- Examine the lengths and gradients of existing slopes.
- Evaluate watershed problems, upstream erosion conditions, and sediment conditions downstream from the construction site.
- Minimize, through proper site planning, the amount of site grading needed for building and utility construction.
- Integrate the clearing and grading with the type of grading technique used.
- Keep clearing to a minimum and preserve as much of the existing vegetation as possible.
- Limit the grading to those areas within the current construction boundaries. Any excess-

sive alterations to lands outside the designated building area are to be avoided.

-Protect disturbed areas by using stabilization measures as soon as possible and stabilize exposed soils by adhering to time limits set out in the schedule for site grading, seeding, and mulching.

-Assure adequate maintenance of all graded areas and all planted areas.

COMPARISON OF GRADING TECHNIQUES

In designing for hillside development, we must first approach subdivision design with a series of grading techniques.

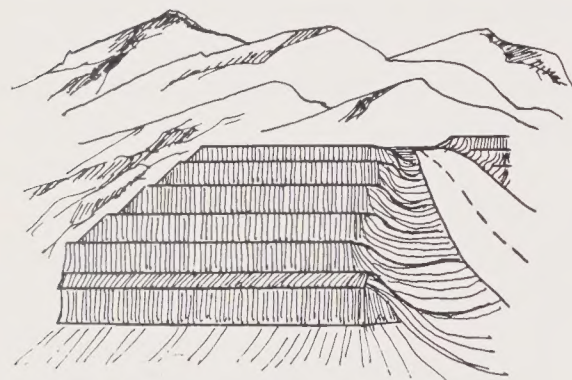
When dealing with these elements, the main objective will be to make new development in the hillside areas compatible with the natural characteristics and suitabilities of the land. It will be a way in which to identify the real variables of a site, such as steep slopes, views, streams, watersheds etc., and means for design of a plan which visually and physically will respond to these variables and will give manufactured hillsides a more natural-looking appearance. Finally, cost analysis is presented, comparing standardized grading techniques to those of landform grading. This will compare the long term economic gains of landform grading with the short-term economic gain of standard grading.

CHARACTERISTICS OF LANDFORM GRADING

Designs include a variety of slope ratios so as to reflect as closely as possible the surrounding natural hills. This helps to avoid the regularity and linearity of 2:1 slopes.

Streets and sidewalks:

Where possible, provide for split level road-



STANDARD 2:1
GRADING



LANDFORM GRADING

ways. These roads would be located in areas where extreme cut and fill would greatly impact steep hillside areas.

Two 20-foot-wide one-way roadways can be designed to perform the function of both drainage and minimizing cut and fill. In open space areas where lots do not join up with the roadways or where parks and open spaces



exist, there should be few sidewalks. Instead, a provision for passenger drop off areas should be incorporated in the design. Safe routes for pedestrians must still be provided. Roads should follow the terrain wherever possible. This will help to reduce construction cost and also keep cut and fill to a minimum.

Ridges and valleys should be avoided if possible and if not, should be located so as to minimize cut and fill. Locations between ridges and valleys are more conducive to road use.

In a development with cluster and multi-family residential structures, roads aligned with countours will create scenic opportunities and quality.

1. Roads can have no curbs. Natural and man-made materials may be incorporated together to maintain landform character.

2. Use bike lanes, natural hiking trails as pedestrian walks, equestrian trails, natural rock drainage ditches, rock catchments, and split level roadways to preserve natural slope contours and minimize cut and fill.

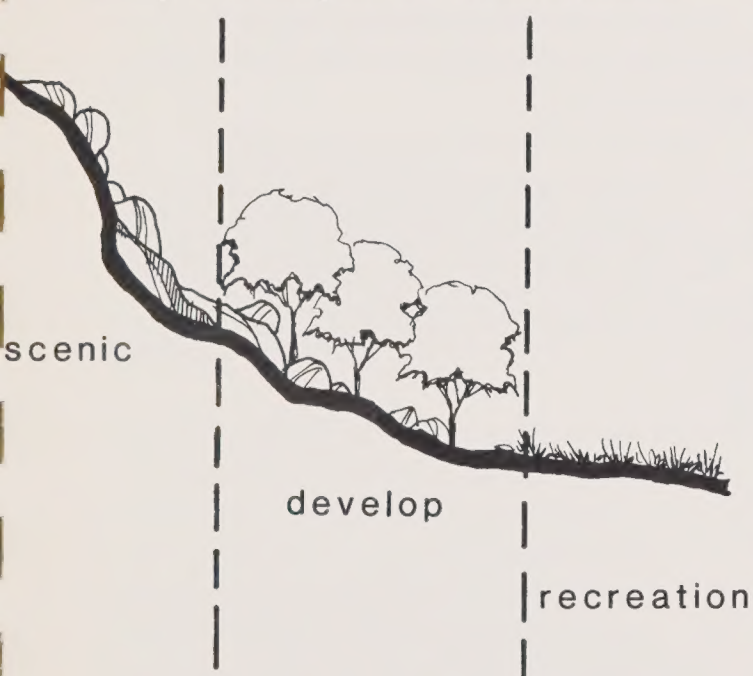
3. Use cul-de-sacs in tightly clustered areas to minimize the paved surface areas and to minimize excess roadway loops in the hillsides.

Multi-family and clustered units should be considered so as to reduce the impact of grading. Clustering allows for a more compact arrangement of buildings especially

in hillside terrain and reduces the alteration of the landscape caused by the installation of infrastructures.

Two areas within the hillside areas should not generally be developed as individual residential holdings: that of steep difficult land, and large areas of gently sloping land.

It can be shown that the steepest land could and should be left untouched for its scenic beauty or be designed in a clustered fashion



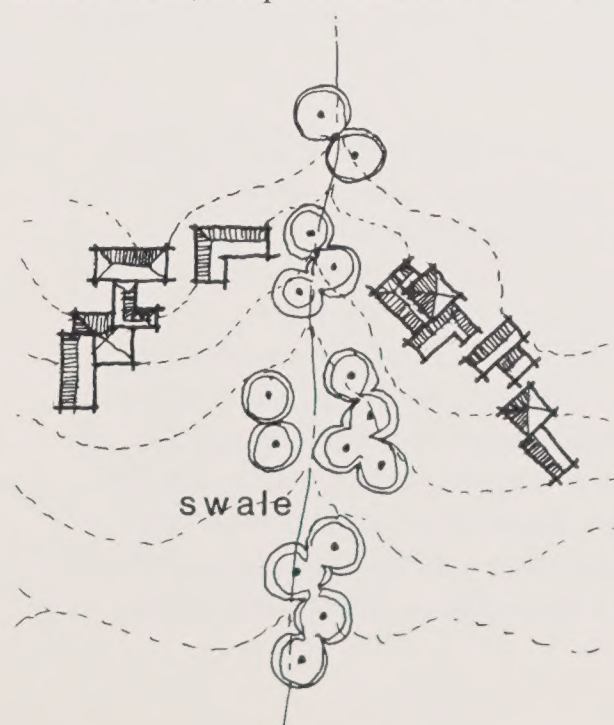
so as to minimize the cut and fill process. The more gradually gentling slopes should be used for parks and community facilities for recreation. The intermediate slopes are better suited to higher density clusters, thus preserving the gentler slopes for community activities which require more level land. Outstanding natural features such as the highest crest in a hillside range, natural rock outcroppings, and particularly desirable vegetation should be preserved as scenic open space.

As a last resort, retaining walls may be considered as an alternate to cut or fill banks.

PLANTING GUIDELINES FOR LANDFORM GRADED SLOPES

Planting in landform graded areas should create a visual appearance of similiar character to nearby natural hillside areas. Swales are the areas of greatest moisture concentration, and are the areas in hillsides where trees naturally group. Trees placed on landform graded slopes should be grouped within swale areas to most closely reflect natural conditions. The swales are areas of greatest moisture concentration, and the portion of hillsides where trees naturally group. Other plantings of shrubs and trees should be placed in irregular patterns similiar to those of natural hillsides.

Vegetation in and around buildings should, to the greatest extent possible, have color and texture similiar to that of the natural landscape. Consideration must be given to maintenance needs, fire protection, and water use.



TECHNIQUES OF STANDARDIZED GRADING:

In standardized grading, a linearity and regularity occurs on the slopes. Usually, a combination of cut and fill techniques are performed in which bring about unnatural horizontal and vertical relief. On the other hand, the standard slopes provide for easy access for buildable pads for the housing structures.

Standard grading is performed to accomplish three main purposes:

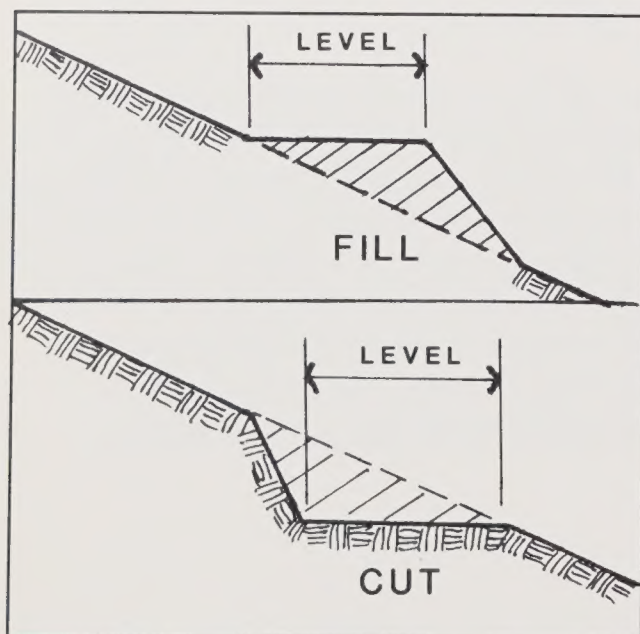
1. To create a level area for a structure or use area such as a garage, horsekeeping area, or a play field.
2. To create circulation routes such as roads, sidewalks, or bike paths at useable gradients.
3. To create special effects or to solve special problems such as screening a parking lot, controlling erosion, or allowing equipment access for maintenance.

Usually, standard grading is performed without consideration for ecologic relationships or patterns. Standard grading can be the simple moving of several cubic yards of earth with a rake and shovel, or a massive operation moving thousands of cubic yards of earth. Grading to make an area level is accomplished by cutting, by filling, or by a combination of cut and fill.

The main advantage of creating a level area by cutting into a bank or slope is that the ground will usually be more stable. Buildings, roadways, and other man-made objects can be constructed on these level areas within hillside areas without special, expensive foundations.

The disadvantage of cutting lies in the need to dispose of the earth which has been cut away. Disposal of the soil requires hauling it to another area, which may incur dumping fees. Further, in this process, precious top-soil is hauled away from the site never to be returned.

Fill is used in areas to make them level and useable. It may be required to fill a low spot, raise an area to reach grade, extend a patio from existing grade, or level a varied terrain to make it more uniform. There are several disadvantages to filling. It may be difficult and expensive to find earth for fills, areas of new fill are not stable and require compaction with special equipment and a lengthy settling



period. Compaction is expensive, and may create problems in areas which are to be planted. Level areas created by filling may also be subject to severe erosion because the soil particles are loose. Slippage and slides can also occur, especially in hillside areas, as there is little or no binding between the existing soil and the fill.

Cutting and filling are usually combined in hillside development areas. The cost of hauling, disposal, and compaction are either lessened or eliminated. Cut and fill is most useful on large sites with moderate slopes where it is possible to balance cut and fill volumes.

Disadvantages to balancing cut and fill in hillside areas arise when there are large areas of greater than moderate slope. Steeper terrain may not allow for on site disposal of cut material and the chances for slippage and erosion are greatly increased.

In general, standard grading practices have been applied to give a greater return in investment by allowing for a maximum amount of building on any given site.

As a result, the higher initial grading costs from the standard practices are offset by the number of units produced.

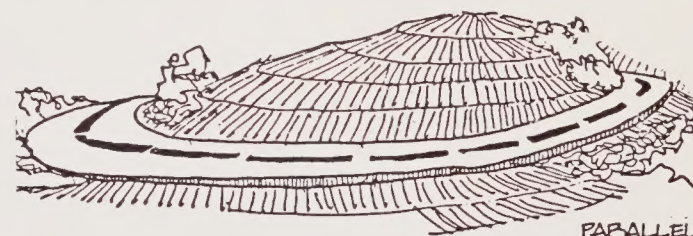
However, the initial costs must be considered not only in the short term as stated here, but in the long term effects. Often, standard grading will result in design which is economically infeasible in the long run. The reason is that standardized grading requires higher maintenance due to the unnatural grading which is being eroded down faster by natural forces than the landform grading.

CIRCULATION

Road alignments in hillside areas are more difficult to design due to steeper terrain and the maximum allowable gradient

In selecting for road alignments, there are two extremes that the alignment can take.

1. Nearly parallel to the contours and rising slightly to gain elevation. This will require extensive grading.
2. Perpendicular to the contours which requires the least grading but will result in the steepest gradient.



The best type of grading for road circulation will be between the two extremes by climbing and falling gently so as to allow the quickest trip with the least effort. They are:

1. Ramping gradually over the distance by going between perpendicular and parallel to the contours.
2. Terracing and switchbacks.

Once either of these methods are established, it will be determined if the grading will take place in cut, in fill, or in a combination of cut and fill.

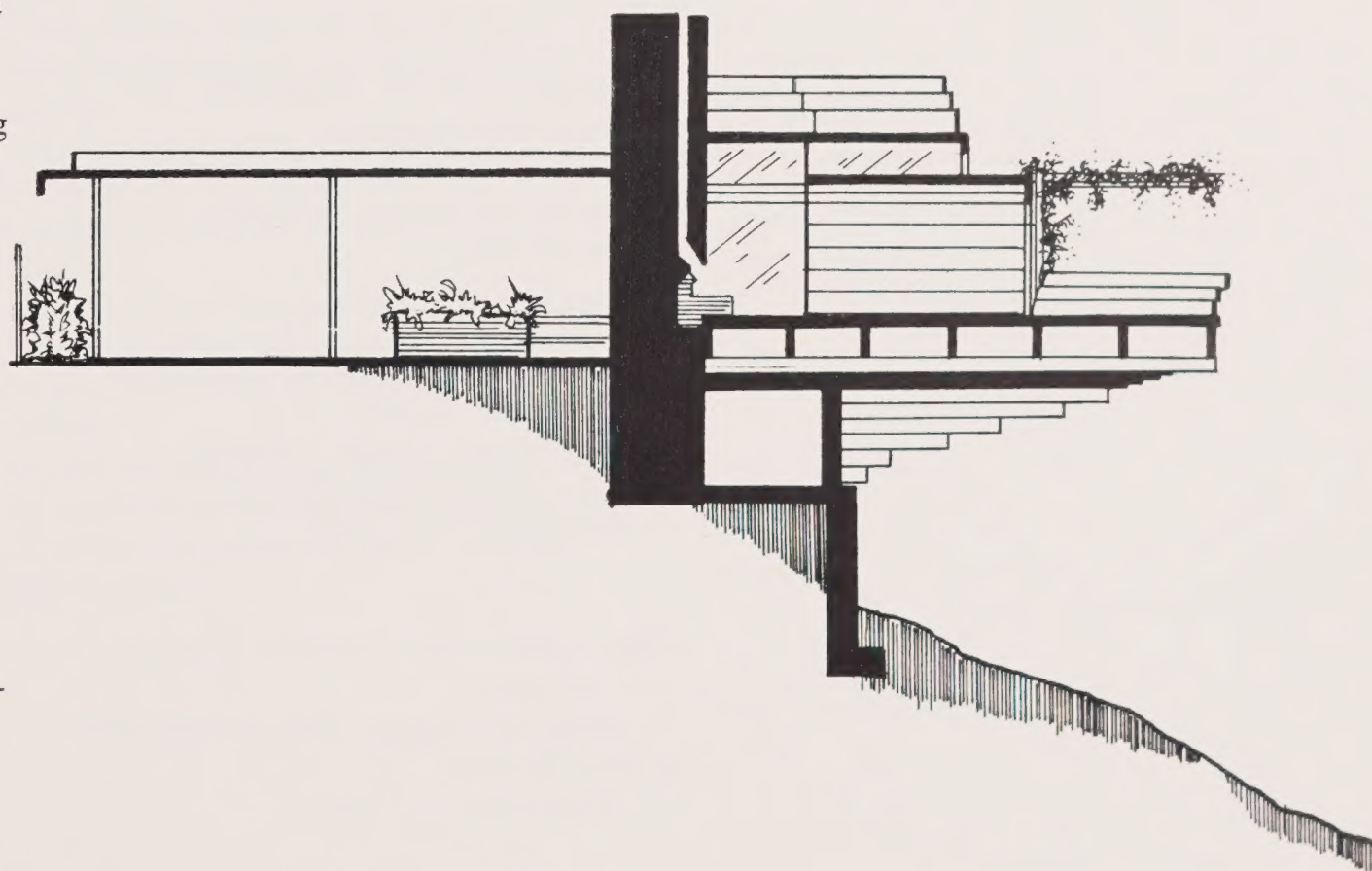
The main purpose though is to provide easy access as much as possible without disturbing the natural contours of the hillsides through intensive cut and fill practices.

CONCLUSION

Landform grading is shown to be a vital role in design and implementation for hillside development. In long term costs, land-forming proves to be more economical in maintenance, due to its conformity to the natural terrain and gradual erosion from physical forces. This provides for visual quality to the homeowners by introducing scenic and wildlife corridors, riparian ecosystems, and recreation.

The task for the developer and anyone involved in the design and implementation for hillside development is to understand and justify all the possibilities for developing a hillside through landform grading and drainage. The justification for developing in hillside areas can only be made through a complete study of the site, the process, and

the general conditions of the environment. A new philosophy must be taken in light of the major impacts stormwater and grading standards are doing in the hillside areas of Los Angeles. We must not only consider the balance of the ecosystem in terms of the natural cycle, but we must provide a means for better land development management. Utilizing a good management approach will not only alleviate the present problems of downstream flooding and siltation, but it will also provide for an added quality of life both to us and to the land we occupy.



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ABOUT THE 606 STUDIO

The 606 Studio is a group of faculty and third-year Master's students in Landscape Architecture at the California State Polytechnic University in Pomona. Within the group, student teams work on different projects and the entire group meets on a regular basis for reviews.

Projects vary in nature, but all involve complex issues in landscape design and natural resource planning. The orientation of the Studio is toward an ecosystematic approach to land planning, integrating human needs with natural processes. Typical projects and topics include:

- Planning and design for new and established communities
- Management and conservation of water resources
- Conservation of energy in the built environment
- Recreation development in the natural environment
- Planning and design for plant and animal habitats
- Ecologically-based design for urban areas, hillsides, and agricultural areas

The academic studio environment offers the freedom for students and faculty to explore issues and possibilities without the economic constraints of professional practice. Even so, the real nature of the projects and the clients' needs demand that projects have a strong practical base, as well as display technical and professional expertise.

Other projects developed this year include:

- A Master Plan for the Lower Arroyo Seco within the City of Pasadena including Design for the Stream Environment for the City of Pasadena
- Landscape Management and Design Guidelines for the City of Coachella
- Revegetation of Degraded Landscapes using Composted Organic Wastes for the City of Los Angeles

Past projects include:

- Mojave River Basin: Design for Desert Water Management for the Mojave Water Agency
- San Jacinto Wildlife Area Draft Development and Management Plan for the California Department of Fish and Game, Region 5
- Design for the Etiwanda/Day Canyon Area for the University of California Natural Reserve System and a Consortium of Landowners
- Landscape Management Plan for Endangered Species at San Clemente Island for the Natural Resources Office, U. S. Navy, North Island.

